The impact of gameful design on sedentary adults' motivation for physical activity and physical activity levels

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(Signature & date required)

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ABSTRACT

Background: Gameful design has been shown to have the potential to increase motivation for and engagement with physical activity (PA). However, at present, there is a significant lack of well-designed frameworks identifying effective pathways to increase PA behaviour.

Purpose: To design a rigorous, methodologically sound, theory-grounded framework for developing gamefully designed PA interventions.

Methods: Intervention Mapping (IM) was used to develop the study protocol, consisting of three studies. *Study 1* encompassed the design of a novel theoretical framework leading to the selection of a gamefully designed PA intervention application. *Study 2* entailed the intervention implementation. Participants (n = 83; mean age = 33.56; females = 48) were randomised to a six-week intervention. Data collection over a six-month period included biometric data, objective measurement of moderate-to-vigorous PA (MVPA) and a detailed PA motivation inventory. *Study 3* presented a process evaluation focused on usefulness, effectiveness and feasibility via a systematic mixed-methods approach.

Results: *Study 1* led to the creation of a new *Taxonomy of Situated Motivational Affordances (SMAs) for Gameful Design*, the establishment of selection criteria for gamefully designed PA applications and the selection of a commercial application (Fitocracy) for the example case pilot intervention. *Study 2* showed no statistically significant change observations in relation to MVPA; however, at six weeks the intervention group showed significant increased levels of identified regulation (internalised motivation) for PA. A significant correlation (p=0.031) between intrinsic regulation and MVPA was verified. *Study 3* determined the usefulness of a systematic methodological study design, a low adoption rate of the intervention application and the appreciation of the complex nature of human motivation in relation to PA.

Conclusions: Gamefully designed applications grounded in theories such as SDT, BCTs and the newly developed *Taxonomy of SMAs for Gameful Design* have the potential to be effective in impacting motivation for PA and PA levels.

ABBREVIATIONS

Abbreviation	Definition
ACSM	American College of Sports Medicine
BCTs	Behaviour Change Techniques
BMA	British Medical Association
BMI	Body Mass Index
BPNT	Basic Psychological Needs Theory
BREQ-2	Behavioural Regulation of Exercise Questionnaire – 2
CDC	Centers for Disease Control and Prevention
CET	Cognitive Evaluation Theory
COT	Causality Orientations Theory
ESA	Entertainment Software Association
GCT	Goal Contents Theory
ICT	Information and Communication Technology
IDC	International Data Corporation
IE	Inland Empire of Southern California
IM	Intervention Mapping
IMI	Intrinsic Motivations Inventory
IPAQ	International Physical Activity Questionnaire
IRB	Internal Review Board
LLU	Loma Linda University
METs	Metabolic Equivalent Units
MPA	Moderate Physical Activity
MVPA	Moderate-to-Vigorous Physical Activity
NHANES	National Health and Nutrition Examination Survey
OIT	Organismic Integration Theory
PA	Physical Activity
PAR-Q	Physical Activity Readiness Questionnaire
PENS	Player Experience of Needs Satisfaction Questionnaire
PPO	Proximal Performance Objectives
RMT	Relationships Motivation Theory
RWJF	Robert Wood Johnson Foundation
SDT	Self-Determination Theory
SMAs	Situated Motivational Affordances
U.S.	United States
USDHSS	U.S. Department of Health and Human Services
WHO	World Health Organization

CHAPTER 1: INTRODUCTION

1.1 Background

The study of health behaviour change related to physical activity is an urgent matter in the face of the steady increase of preventable chronic diseases and early death, particularly in the Western world, that can be linked to physical inactivity (World Health Organization, 2010). Physical inactivity is the fourth leading cause of death globally, with 3.2 million people dying each year and with 60% of the world's population not getting sufficient exercise (Lim et al., 2012). According to the Centers for Disease Control and Prevention (CDC), 79.6% of the United States (U.S.) adult population did not meet the physical activity guidelines for aerobic and muscle-strengthening activities in 2010. Of all adults in the U.S., 53.5% are not sufficiently active throughout the day overall, with 65.9% of women and 41.1% of men not being sufficiently physically active (Loprinzi et al., 2016). A clear decline of 13.8% in daily physical activity can be observed between the ages of 20 to 59 among the overall population, indicating that physical activity levels decrease in the U.S. as people age, beginning as early as in the twenties (Loprinzi et al., 2016). The Sedentary Lifestyle Index (Tudor-Locke et al., 2013) defines being physically inactive as taking fewer than 5000 steps per day, and thus living a sedentary lifestyle. Less movement indicates higher levels of sedentarism; thus, as physical activity levels decline, sedentary behaviour continues to increase and can cause serious harm to health and longevity (Raynor et al., 2012).

There are many known barriers to being physically active among adults. A significant number of them relate to motivation: not finding exercise enjoyable or a lack of encouragement, support, and confidence in one's abilities and social support (Sallis, Hovell & Hofstetter, 1992). One answer to the current physical inactivity epidemic is to remove these barriers to increase motivation for physical activity behaviour (Michie et al., 2011). To be able to find evidence-based pathways to motivation, it is essential to employ an established and proven theory.

Self-Determination Theory (SDT) (Deci & Ryan, 1985) is a well-established and comprehensive theory of human motivation, articulating a meta-theory and providing a theoretical framework for research. SDT outlines different components that move people to act, sitting on a spectrum of self-determination from extrinsic motivation to intrinsic motivation, which is characterised by the satisfaction of the three basic psychological needs: autonomy, competence and relatedness (Ryan et al., 2008). SDT concepts have been successfully linked with physical activity behaviour, and research relating to this connection has increased considerably in the past eight years (Teixeira et al., 2012). Recently, SDT has also been linked to a phenomenon labelled "gameful design". Available research shows that gameful design can increase motivation (Hamari, Koivisto & Sarsa, 2014; Lister et al., 2014; Seaborn & Fels, 2015). Game elements can serve particular psychological functions, which create motivational pull toward engaging in certain sustained behaviours (Sailer et al., 2013). 63% of American households play computer and video games, with the game player's average age being 35, and 73% are age 18 or older (Entertainment Software Association, 2015). Further, 88% believe that game play is fun for the entire family, providing opportunities to connect across the age ranges (Entertainment Software Association, 2015), indicating that using gameful design holds broad appeal. All this suggests that gameful design, guided by and theorised through SDT, may provide a promising framework for a successful health behaviour change intervention.

The connection between games and physical activity is not a new one: in 2006 the Nintendo Wii hit the market ushering in the era of “exergaming”, where the player has to engage in some type of physical movement while playing the game (Osorio, Moffat & Sykes, 2012). However, while the integration of gameful design, technology and physical activity has become a new area of interest and exploration, it is currently still lacking rigorous research (Kato, 2012). Specifically, there are few rigorously designed, theoretically guided, long-term studies that track actual health behaviour change (Hamari, Koivisto & Sarsa, 2014; Pereira et al., 2014; Seaborn & Fels, 2015).

1.2 Research Design

Apart from the general lack of evidence, Helf and Hlavacs (2016) observed in their review of gamefully designed health behaviour intervention applications that the field lacks a strategic approach to selecting and/or developing interventions, as is now common in evidence-based health promotion models. Specifically, they suggest the use of Intervention Mapping (IM) for creating health interventions that integrate the interdisciplinary areas of gameful design and health behaviours (Helf & Hlavacs, 2016; cf. Crutzen, 2014; Bartholomew et al., 2011).

DeSmet et al. (2016) applied IM to serious game design addressing cyberbullying and successfully determined an effective behaviour based on the integration of evidence and theory, supported by the IM design. Arnab and Clarke (2015) note the general lack of frameworks and systematic methodologies within game-based intervention development, making it difficult to replicate efforts of single-disciplinary studies. They suggest a fusion of trans-disciplinary approaches, utilising existing evidence-based frameworks and models from other scientific subject areas, and exemplify such an approach based on a digital game intervention related to education (Arnab & Clarke, 2015). In this case, IM was utilised as an example of a rigorous methodology providing a systematic, theory- and evidence-based procedural approach to building the foundation of a trans-disciplinary protocol for digital game intervention design. Arnab and Clarke (2015) conclude that the integration of this existing framework, usually applied to health-related contexts, highlighted feasibility in their trans-disciplinary approach and suggest it can be adopted by other researchers.

DeSmet et al. (2016) and Arnab and Clarke (2015) showcase examples of promising application of IM in the context of serious game design. Serious games are not synonymous with gamefully designed contexts; however, they are an adjacent subject area, and thus can serve as a lead example showcasing potential for application of IM in the gameful design arena, as no known IM approaches specifically coupled with gameful design interventions for physical activity exist at this time.

IM is an ecological model and planning protocol for developing health promotion programs based on the premise that effective interventions must be grounded in evidence-based practical problems and theoretical context (Bartholomew et al., 2011). In a recent health promotion intervention, Ammendolia et al. (2016) conclude that IM provides useful methods for program design due to its detailed process for addressing complex problems. IM assisted with identifying strengths and weaknesses of the existing programmatic elements and helped prioritize the main health issues, which led to the development of clear strategies of addressing the problems (Ammendolia et al., 2016).

The traditional IM approach (Table 1.1) consists of six main steps, which can be used iteratively rather than linearly: (1) needs assessment; (2) matrices of change objectives and their determinants; (3) theory based methods and practical strategies to modify the behavioural and environmental determinants; (4) production of program and materials; (5) planning for adoption and for the implementation plan; and (6) evaluation planning (Bartholomew et al., 2011). Health promotion planners can move back and forth between the different steps and tasks to reach the outcomes of the process. IM focuses on linking theory and evidence with the intervention, identifying specific learning and change objectives as well as their determinants (McKenzie, Neiger & Thackeray, 2012).

The successful application of IM for planning health promotion programs (Bartholomew et al., 2016) and the evidence of its promising usage within serious game intervention design (DeSmet et al., 2016; Arnab & Clarke, 2015) supported its choice as the guiding framework for the purposes of this study. Table 1.2 showcases the application of IM coupled with the research design of this thesis. As indicated by Bartholomew et al. (2016), IM allows program planners to move iteratively between the outlined steps depending on the specific contextualised program design situation. Based on the research questions outlined below and the nature of the novel multidisciplinary approach of integrating gameful design, SDT and physical activity behaviour to design a new methodological approach, it will be necessary to apply IM slightly non-sequentially to present the complete research process in a logical, systematic way. Thus, steps three and four follow step one prior to the application of step two (see Table 1.2).

Table 1.1: Intervention Mapping

E V A L U A T I O N	**STEP 1**	**Needs Assessment**	Assess health problem, population & determinants
	STEP 2	**Matrices**	State expected changes, specify population, performance objectives, determinants & change objectives
	STEP 3	**Theory & Practice**	Choose program methods and select strategies
	STEP 4	**Program**	Develop design materials and protocols
	STEP 5	**Implementation**	Identify adopters, users & implementation conditions
	STEP 6	**Evaluation**	Describe program outcome and effects; question, specify evaluation design
	← **I M P L E M E N T A T I O N**		

Source: Adapted from Bartholomew et al. (2011)

Given that (1) there is a societal need to address decreasing physical activity behaviour, particularly among sedentary adults; (2) increasing motivation for physical activity is a viable strategy to increase physical activity levels; (3) SDT provides a sound theoretical framework for understanding physical activity-related motivation; (4) gameful design is a promising tool to impact motivation for physical activity; (5) rigorous, longitudinal data on the actual behavioural effectiveness of gameful design on physical activity behaviour is lacking, and (6) theory-grounded

methodological frameworks informing the selection and/or design within this field are lacking, the overarching research question for the current thesis is:

RQ1: *How can a systematically designed theoretical framework inform the development of gamefully designed physical activity interventions?*

Specifically, to assess the impact of a theory-driven gamefully designed intervention on physical activity behaviour, the following research questions were set:

RQ2: *How feasible, useful and effective is a theory-informed methodological selection and implementation process for gamefully designed physical activity interventions?*

RQ3: *How does a gamefully designed physical activity intervention impact the motivation for physical activity, engagement with the intervention application and physical activity levels among sedentary adults?*

To answer these research questions, I developed specific objectives and adopted a multi-study, mixed-methods approach involving three studies using the IM approach (Table 1.2). *Study 1* develops a methodological approach to design or select a gamefully designed physical activity application, which resulted in a concrete implementation evaluated in *Study 2*. *Study 2* entailed the implementation and quantitative evaluation of a case example of a gamefully designed physical activity intervention. Lastly, *Study 3* evaluates the design, selection and implementation processes.

Study 1 informs *Study 2* and *Study 3*, and the respective findings circulate back to inform the IM process for evaluation and revision. For the purpose of this thesis, *Study 1* shall be referred to as “Theoretical Framework Design Study”, *Study 2* shall be referred to as “Intervention Implementation Example Case Study” and *Study 3* shall be referred to as “Process Evaluation Study”.

Chapter 2 expands on showcasing the extent of the major health concern of physical inactivity with a particular emphasis on the U.S. population. Further, it presents a detailed exploration of a possible solution grounded in SDT and gameful design and a thorough review of the current research related to gamefully designed physical activity interventions. Chapter 3 (*Study 1*) details a systematic evaluation of interdisciplinary concepts related to behaviour change techniques, SDT, motivation and gameful design, resulting in the development of a theoretical framework for the design or selection of an appropriate intervention application. The newly designed framework is then used to conduct a thorough review of existing gamefully designed physical activity applications to determine which is a suitable selection for application for a case example. Chapter 4 (*Study 2*) presents all aspects of the case example of the implementation of the selected gamefully designed intervention. Chapter 5 entails a process evaluation, investigating the feasibility and acceptability of the selection and implementation processes (*Study 3*). The findings of each study are tied together in an overall evaluation of the research design and outcomes in a detailed discussion in Chapter 6.

Table 1.2: Thesis Research Design

Thesis Research Design	Research Objectives	Intervention Mapping
Chapter 2: Literature Review	N/A	**STEPS 1 - 5**
Chapter 3: Theoretical Framework Design **(STUDY 1)**	1. To review advanced theoretical concepts of SDT and gameful design 2. To identify possible connections between SDT, gameful design and health behaviour change 3. To review existing frameworks of health behaviour change techniques (BCTs) theoretically and applied in the context of physical activity and computing technology 4. To design a theoretical framework based on the theoretical bases to inform the selection of an intervention for *Study 2* 5. To select an intervention for *Study 2*	
Chapter 4: Intervention Implementation Example Case **(STUDY 2)**	1. To implement and evaluate the impact of a gamefully designed physical activity application on moderate-to-vigorous levels of physical activity (MVPA) of sedentary adults at baseline, six weeks, three and six months. 2. To assess the impact of a gamefully designed physical activity application on the mediating outcome of internalised motivation measured at baseline, six weeks, three and six months 3. To estimate the variance in the primary outcome to inform sample size calculations for a definitive randomised controlled trial 4. To evaluate the effects of increased intrinsic motivation on levels of physical activity	
Chapter 5: Process Evaluation **(STUDY 3)**	1. To estimate recruitment and participation rates 2. To assess adoption, usage and retention rates 3. To assess how useful and practical the *Taxonomy of SMAs for Gameful Design* was in selecting an intervention 4. To evaluate the mechanisms of impact, including SMAs, on motivation for PA and PA behaviour 5. To assess the effectiveness of the delivery mechanisms 6. To evaluate the influence of external factors 7. To estimate resource use and costs	**STEP 6**
Chapter 6: Discussion	N/A	N/A

CHAPTER 2: LITERATURE REVIEW

This review expands on establishing what physical activity, physical inactivity and sedentary behaviours are and how they connect to health. The current state of the situation related to these concepts is presented, with a particular focus on the U.S., laying the foundation for the need of an intervention to find possible pathways for changing the decline of physical activity behaviour among adults. Further, the literature presented shows how motivation is a crucial piece of increasing physical activity behaviour and why SDT is a good model for designing a theoretical foundation for the design of an integrated intervention study. Gameful Design will be discussed as a promising strategy for impacting motivation for physical activity. Based on the presentation of these concepts, a review of existing research is presented, highlighting the current knowledge, gaps and future research direction suggestions. The findings of this literature review build the foundation for the studies in this study.

2.1 Physical Activity and Sedentary Behaviours

2.1.1 Physical Activity and Physical Fitness

Physical activity is defined as any form of movement carried out by the skeletal muscles that requires energy (Fahey, Insel & Roth, 2011). Physical activity is essential to optimal health and wellbeing and provides a wide variety of physical and mental health benefits. Exercise is a subset of physical activity indicating that activity is intentional, planned out, structured and purposeful movement, done repeatedly and intended to improve or maintain physical fitness (CDC, 2015). Physical fitness refers to the ability to carry out everyday duties and leisure-time activity being fully alert and full of energy, without easily getting tired and with the stamina to respond to possible emergencies (CDC, 2015). Health-related physical fitness consists of five components: cardiorespiratory endurance, muscular strength, muscular endurance, flexibility and body composition (Pescatello et al., 2014).

For the purpose of improving overall health, the American College of Sports Medicine (ACSM) recommends that adults should get at least 150 minutes of moderate-intensity physical activity per week for cardiorespiratory fitness. In addition, adults should exercise each major muscle group two to three times per week using a variety of strength training methods for muscular strength and endurance fitness. Flexibility fitness should be practiced two to three times per week at minimum addressing each major joint and utilising the static stretching method; however, five to seven times would be ideal (Pescatello et al., 2014).

Systematic research in the U.S. about the relationship between physical fitness and health did not begin until the 1960s (Pescatello et al., 2014). However, there is evidence that throughout history, humans have understood this connection. There are records from ancient China that indicate exercise was viewed as a way to promote health as early as 2,500 B.C. The ancient Greeks are also known to have placed great emphasis on physical fitness and health (MacAuley, 1994). In 1996, the U.S. Surgeon General published a report (Physical Activity and Health), which outlined the many health benefits available from being physically active (USDHHS, 1996). These observations

were reiterated in the publication of the 2008 Physical Activity Guidelines for Americans by the U.S. Department of Health and Human Services (USDHHS).

Example benefits of regular physical activity are: improved cardiorespiratory function, increased maximal oxygen uptake resulting from central and peripheral adaptations, decreased resting heart rate, decreased blood pressure, increased serum high-density lipoprotein cholesterol, decreased serum triglycerides, decreased morbidity, decreased mortality, lower incidences of cardiovascular disease, reduced risk for stroke, reduced risk for many chronic diseases, decreased anxiety and depression, improved cognitive function, reduced risk of many types of cancer, improved sleep, increased energy, better weight management, enhanced self-esteem and many more (Pescatello et al., 2014; Marcus & Forsyth, 2009).

2.1.2 Physical Inactivity and Sedentary Behaviour

The U.S. National Health Interview Survey report (USDHHS, 2008) classifies adults as being physically inactive if they do not have at least 10 minutes of light-to-moderate or vigorous leisure-time physical activity in one day. According to the National Population Health Surveys of Canada, people are classified to be physically inactive if they walk fewer than 3,000 steps per day, or fewer than 1.3 miles (a little over two kilometres). Tudor-Locke et al. (2013) classify individuals as being physically inactive when logging fewer than 7,500 steps per day (Figure 2.1).

Further, Tudor-Locke et al. (2013) define a sedentary lifestyle as "non-exercise physical activity deficiency; lack of movement; higher accumulated time in sedentary behaviours" (p. 103; see Figure 2.1). Pate, O'Neill and Lobelo (2008) define sedentary behaviour as expending fewer than one-and-a-half metabolic equivalent units (METs), which can be equated with sitting still. Recent research by Raynor et al. (2012) investigating time spent being sedentary, independent from intentional physical activity, shows that sedentary behaviour imposes a greater risk for the development of chronic diseases such as cardiovascular disease, type 2 diabetes, weight gain and metabolic syndrome. Ramazzini, an occupational physician, found a relationship between sedentary behaviour and harmful health consequences in workers as early as the 17th century (Franco, 1999).

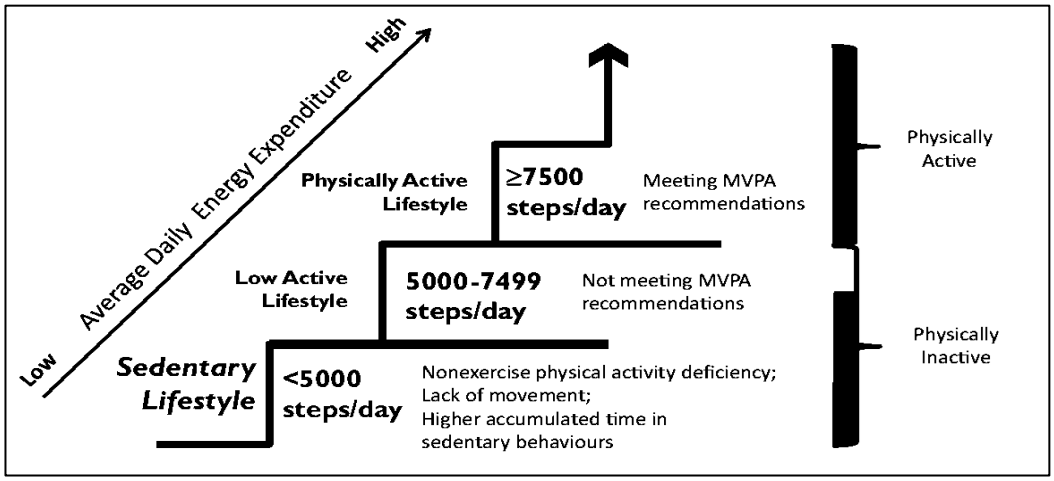


Figure 2.1: Step-defined Sedentary Lifestyle Index for Adults (Tudor-Locke et al., 2013)

Physical inactivity is the fourth leading cause of death globally with 3.2 million people dying each year (Lim et al., 2012). Furthermore, the WHO reports that about 60% of the world's population is not getting sufficient exercise, partly due to the decrease in physical demands at the work place, the increase in technology and mechanisms and the decrease in recreational activities (2010).

In the United States (U.S.), 79.6% of the adult population does not meet the physical activity guidelines for aerobic and muscle-strengthening activities (CDC, 2010a). Among the U.S. adult population, 53.5% are not sufficiently active throughout the day (Loprinzi et al., 2016). Between the ages of 20 to 59, a decline of 13.8% in daily physical activity can be observed (Loprinzi et al., 2016), indicating an important trend, namely that physical activity levels decline as people age. These recent findings correspond with earlier data from the CDC (2010a) showing that approximately one-half of the U.S. population is not regularly physically active and 25% are not active at all. More than two-thirds of American adults are overweight or obese, and childhood obesity has tripled in the past two decades (CDC, 2010b). 33.8% of adults and 17% of children and adolescents in the U.S. are considered obese and approximately 300,000 premature deaths occur annually that are directly related to obesity (CDC, 2010b). As rates of physical activity decrease, rates of sedentary behaviour drastically increase.

Younger baby boomers (ages 45 to 54) average the highest daily screen time of just over nine-and-a-half hours, whereas the average screen time for all age groups was roughly eight-and-a-half hours per day (Council for Research Excellence, 2009). Screen time is typically associated with sedentary behaviour, such as sitting. Sitting occurs in a variety of settings, such as the work place, transportation, recreational activities and screen time, including television, computer and video games. Recent research suggests that health risks increase greatly by time spent being sedentary independently from insufficient structured physical activity (Owen et al., 2010).

Sedentary individuals are at much greater risk to develop diabetes (type 2), metabolic syndrome and cardiovascular disease (Grøntved & Hu, 2011) and are much more likely to gain weight (Mozaffarian et al., 2011) and become obese (Hu et al., 2003). In addition, according to the evidence, sedentary behaviour is an independent risk factor for all-cause mortality (Raynor et al., 2012). Engaging in prolonged sedentary behaviours has a variety of deleterious health effects impacting the individual, society, education and governmental agencies. It is essential to research and understand pathways by which sedentary time can be reduced and thus physical activity increased (Raynor et al., 2012). However, it is essential to understand how physical activity levels are measured and which options present the most accurate way to inform the development of an effective physical activity intervention. The next section presents an overview of different options for physical activity measurements and related research findings informing future best practices.

2.1.3 Measurement of Physical Activity and Sedentary Behaviours

Physical activity levels can be measured in a variety of ways utilising different methods. Traditional methods of obtaining this data typically include self or proxy reports (Reilly et al., 2008); however, over the past decade and a half, objective methods have been increasingly used and have become commonplace within physical activity research (Bassett, 2012). Objective methods of physical activity measurement include the usage of a small

wearable monitor, such as an accelerometer, pedometer or heart rate monitor. Research shows that there are definite advantages to objective measurement, as these devices produce unbiased data for physical activity and sedentary behavioural patterns (Reilly et al., 2008).

Pedometers are devices that count the number of steps a person takes. Modern-day pedometers are usually designed using one of two principles: (1) a spring-suspended lever arm accumulating the number of steps; or (2) a piezo-electric or piezo-resistive accelerometer recording instantaneous acceleration multiple times per second (Bassett, 2012). Research shows that spring-levered systems seem to be less accurate, particularly with obese, pregnant and slow-walking individuals (Connolly et al., 2011). An advantage to using pedometry is that it is relatively cheap and the devices are easy to use. A clear disadvantage is that pedometers do not have the capability to distinguish the intensity of physical activity, such as in walking versus running (Bassett, 2012).

Accelerometers have the ability to measure the intensity of physical activity as well as the number of steps taken. Many of the newer options, such as the Actigraph wGT3X monitor, can also measure sleep and wake measurements, energy expenditure, MET rates and subject position. Unlike pedometers, accelerometers are not influenced by different body compositions, such as normal weight, overweight or moderate obesity (Feito et al., 2011). This verifies that waist-mounted accelerometers can be utilised for accurate data collection in people with varying body mass index (BMI) scores (Bassett, 2012). New devices are continuously being designed to perfect the technology in order to obtain more accurate physical activity results.

A subjective measure such as self-reporting can inflate physical activity levels as it is based on participants' perceptions, which can create a false sense of population trends (Reilly et al., 2008). Furthermore, subjective methods can add false perceptions regarding socio-economic and ethnic groups in relation to physical activity levels. Interesting findings from the National Health and Nutrition Examination Survey (NHANES) (2003–2004), which used ActiGraph accelerometry, revealed that Hispanics have a higher physical activity level than blacks or whites, who appear to have similar activity levels (Troiano et al., 2008). Previous research relying on self-reporting methods showed that whites were more physically active than blacks (Ahmed et al., 2005; Whitt-Glover et al., 2007).

In addition to determining physical activity levels among the population, it is vital to understand why people may choose not to engage in daily physical activity and structured exercise so that solutions can be found to reverse the discouraging trends of physical inactivity. Being physically active has been shown to have many health benefits, including the ability to prevent and reverse the development of many chronic diseases. Particularly in the U.S., a rapid decline of physical activity levels among all age groups has been observed in recent years, linked to the development of the obesity epidemic (CDC, 2010b). This physical inactivity epidemic is causing great concern to governmental leaders, health care systems, educational systems and society at large worldwide. Many physical activity interventions have been tried and tested over several decades; however, enhanced evidence in the real world is needed in order to determine the effectiveness of such interventions (Roberts & Treasure, 2012).

2.2 Motivation and Self-Determination Theory

2.2.1 Introduction

The identification of barriers to physical activity is a vital component in developing effective interventions to improve physical activity levels. Modern technological advances have changed the tasks of daily life, making many processes and tasks much more convenient, but also less active (CDC, 2011). In addition, there are numerous variables that impact an individual's physical activity levels, which can include physiological and behavioural factors (CDC, 2011), many of which can be modifiable. The ten most common reasons adults provide for not being more physically active (Sallis & Hovell, 1990; Sallis, Hovell & Hofstetter, 1992) are outlined in Table 2.1.

Table 2.1: Ten Most Common Reasons for Being Physically Inactive

- Insufficient time to exercise
- Inconvenience of exercise
- Lack of self-motivation
- Non-employment of exercise
- Lack of confidence in ability to be active
- Fear of injury
- Lack of self-management skills
- Lack of encouragement, support or companionship
- Non-availability of access to facilities (parks, etc.)

Source: Sallis & Hovell, 1990; Sallis, Hovell & Hofstetter, 1992

Motivation factors strongly across these reasons: lack of self-motivation is one of the top three reasons, but non-enjoyment, boredom, lack of self-efficacy, fear and lack of social encouragement are all motivational constructs (Reeve, 2016). Motivation refers to the psychological processes that energize and direct behaviour (Reeve, 2016). Motivational research is in a state of post-paradigmatic pluralism, with no single overarching theoretical framework. A recent count found more than 40 theories in active use across motivational research (Reeve, 2016). When it comes to physical activity, again we find numerous frameworks in active use (Reeve, 2016). One theory that is finding increasing use and support in physical activity motivation is SDT (Teixeira et al., 2012).

2.2.2 Introduction to SDT

SDT is a far-reaching theory of human motivation, identifying what moves people to act, including external and internal factors. SDT assumes that people are active organisms with innate tendencies towards growth, which requires continuous social support (Ryan & Deci, 2000). This social environment can either reinforce or prevent the natural tendencies towards development, engagement and growth. SDT asserts that every human being has three basic psychological needs that need to be satisfied for a human to grow and flourish: autonomy, competence and relatedness (Ryan & Deci, 2000). The degree to which the needs are met impacts the level of wellbeing in that particular context. Because of this, human beings spontaneously seek out and continue to engage in activities that satisfy these three innate needs and will self-report enjoyment of such activities. This is SDT's explanation of intrinsic motivation—why people engage in certain activities for their own sake, and what makes these activities inherently engaging and enjoyable (Ryan & Deci, 2000). Humans are also motivated by a large number of things that are external to a person and/or a separable outcome of an activity, which SDT labels as extrinsic motivation. SDT posits a spectrum of self-

determination based on the perceived locus of causality: to what extent people perceive themselves to be the origin of their actions or compelled to act by other entities, with extrinsic motives like punishments or rewards being the least self-determined and intrinsic motivation being the most self-determined. More concretely, SDT research has resulted in the evolution of six formal mini-theories that explain different motivational phenomena or ways personalities function.

The Basic Psychological Needs Theory (BPNT) suggests that there are three psychological needs: competence, autonomy and relatedness (Ryan & Deci, 2000). Competence refers to the need to feel capable of achieving tasks and goals. Autonomy refers to one's need to act with one's own willingness and volition and in congruence with one's own goals, values and identity. Relatedness represents the need to feel connected to other people and be understood. Contexts and opportunities where these needs are satisfied are typically inherently enjoyable in the same way it is enjoyable to have physical needs met. They give rise to intrinsic motivation, which will drive behaviour (Ryan & Deci, 2000).

The Organismic Integration Theory (OIT) argues that organisms are not just intrinsically motivated, but are also moved by motives brought to them by their environment. Organisms have an active *integrating* tendency: they internalise motives brought to them from their family, peers, etc. OIT makes out a spectrum of internalisation with several sub-forms of extrinsic motivation: external, introjected, identified and integrated regulation (Figure 2.2). The greater the internalisation of extrinsic motivation, the greater the relative autonomy of the behaviour in question.

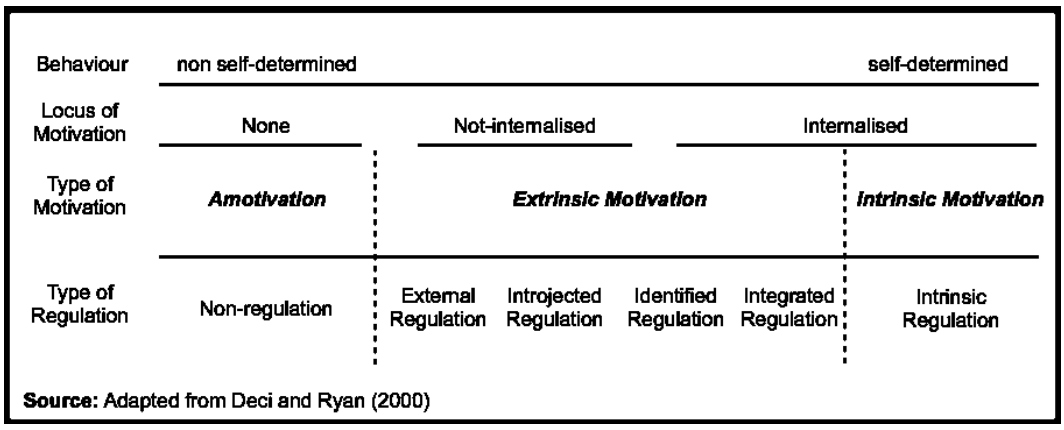


Figure 2.2: Self-Determination Continuum (Deci & Ryan, 2000)

Amotivation lies on the left of the continuum and refers to the absence of motivation. Extrinsic motivation is placed at the centre of the continuum and is further detailed by four sub-categories. External regulation is the least self-determined type and refers to doing an activity for some type of reward, such as money, or through force or to avoid a penalty. Introjected regulation has a slightly higher level of internalisation. Here, people internalise something from the outside world that compels them to do something into internal demands, e.g., guilt or wanting approval of others. Identified regulation refers to the type of motivation that is related to one's conscious value for something, although it is still external. The activity may be beneficial for achieving an academic or professional goal and is therefore important; however, it may still not be enjoyable in itself.

Lastly, integrated regulation is the most internalised form of external motivation in that it reflects an agreement between personal values and beliefs with external motivations. One clearly sees an alignment between personal beliefs and external motivations and feels a particular action is the right thing to do, regardless of enjoyment. Specifically, it means that an external value is well integrated with other motives and values within one rather than being in conflict with them. Intrinsic motivation lies at the very right of the continuum and is described in detail in the CET. It refers to the type of regulation that motivates a person to act without the need for encouragement, because the activity is so enjoyable in itself.

The Cognitive Evaluation Theory (CET) is concerned with the influences of the social environment on intrinsic motivation and how issues such as rewards and interpersonal controls affect interest and intrinsic motivation. CET argues that environmental stimuli may thwart autonomy or support competence based on how people interpret these stimuli. If people perceive, for example, verbal praise as *informative*, intended to indicate or guide successful performance, this will support the experience of competence. If people perceive the same stimulus as *controlling,* intended to externally compel a person to act in a certain manner, it will thwart autonomy.

The Causality Orientations Theory (COT) extends the typology of motivations into a classification of stable personality traits or orientations. If people across situations act because they are interested in or value what is happening, they are said to be autonomy-orientated. Control orientation in contrast indicates a cross-situational focus on approval, gains and rewards, which can result in rigid functioning and decrease levels of wellbeing (Deci & Ryan, 2000). COT is very helpful in determining psychological health and behaviour.

The Goal Contents Theory (GCT) describes the concept that everyone has long-term life goals that guide one's activities. There are two types of goals: extrinsic and intrinsic. Extrinsic goals include things such as financial success, fame and appearance. These types of goals have been associated with lower levels of wellness and health (Deci & Ryan, 2000). Intrinsic goals include close relationships, personal development and community. These goals will contribute to greater health and wellbeing.

The sixth and last mini-theory has been added recently and is referred to as the Relationships Motivation Theory (RMT). This theory is concerned with the social relationships between people in varying contexts. The most successful relationships occur in a scenario in which each partner adequately supports the other's needs for autonomy, competence and relatedness within the relationship, which in turn can further motivate desired behaviour (Deci & Ryan, 2014).

These six mini-theories comprise a meta-theory of SDT with some repetitive yet clear concepts weaving throughout each mini-theory. Further, this overview showcases the versatility of the theory in that it can be applied to a variety of contexts, including physical activity behaviour. The next section presents evidence that SDT is a well-validated theory for understanding and driving physical activity motivation.

2.2.3 Physical Activity and SDT

The earliest available published research evaluating SDT in the context of physical activity is from 1987. Vallerand, Deci and Ryan (1987) reviewed the

concept of intrinsic motivation in relation to sport. Since then, a plethora of study publications have emerged, particularly focusing on SDT in relation to physical education settings and sports-related topics and contexts, validating the concept's relevancy and application within research (Deci & Olson, 1989; Frederick-Recascino & Ryan, 1995; Vallerand & Losier, 1999; Van de Berghe et al., 2014). More recently, greater interest in applying SDT to physical activity more broadly can be observed. However, the majority of published research still focuses on sports and physical education-related settings.

Teixeira et al. (2012) conducted a comprehensive review of empirical literature, examining the relationship between key SDT-based constructs and behavioural outcomes of physical activity. Their review identified 66 published studies (up to June 2011) focused on SDT-based interventions in exercise. A key finding across studies is a strong positive relationship between degree of perceived autonomy or self-determination and positive physical activity, identified regulation in particular predicting initial and short-term behaviour (Teixeira et al., 2012). Further, competence emerged as another positive predictor for physical activity participation. Overall, findings confirmed that the greatest predictor for long-term adherence to structured physical activity is intrinsic motivation. Interestingly, Teixeira et al. (2012) assert that the "clearest finding of this review concerns the beneficial role of developing autonomous self-regulation, be it predominantly via autonomous forms of extrinsic regulation (i.e., identified and integrated regulation) or enhanced intrinsic motivation" (p. 26). They recommend that future work should collect data over a longer term, including follow-ups to measure exercise maintenance, with a particular focus on relative efficacy of identified versus intrinsic regulations.

Teixeira et al. (2012) conclude that there is substantial evidence for the value of using SDT in studying physical activity behaviour and informing the design of physical activity interventions, as interventions that deliver on core SDT constructs like autonomy have been found to make a positive difference in many people's lives (Teixeira et al., 2012). Future research recommendations suggest the usage of outcome measurements related to actual improvements in physical activity levels, fitness and health outcomes in addition to behavioural engagement data. Even outside physical activity research has demonstrated clear links between health behaviours and intrinsic motivation (Patrick & Williams, 2012; Teixeira et al., 2012; Fortier et al., 2012).

Effective health behaviour interventions require grounding in well-supported theoretical frameworks (Helf & Hlavacs, 2016). SDT provides a well-validated theory for understanding motivation in relation to physical activity behaviour; thus, approaching the design of a gamified physical activity promotion intervention with SDT appears sound. This is particularly the case as SDT is the most frequently used theory in gameful design research, which leads us to the next section.

2.3 Gameful Design

2.3.1 Background and Introduction to Gameful Design

From the beginning of recorded culture, games have been used as a means for entertainment, social engagement, training and even survival (McGonigal, 2011). Despite broad cultural differences, games across cultures seem to have some key common features, including quantifiable outcomes, value-

laden outcomes, rules, player effort, player investment and negotiable consequences (Juul, 2003).

What games of all different kinds have in common is that they are built for enjoyment and engagement (Deterding, 2011). Well-designed games are enjoyable and engaging, creating strong experiences that satisfy basic psychological needs, which asserts that they are intrinsically motivating (Przybylski, Rigby & Ryan, 2010; Tamborini et al., 2011; Mekler et al., 2014).

Beyond serious games, video games have drastically infiltrated current society in more recent years. Data from 2015 (Entertainment Software Association) shows that 155 million Americans play video games and the average age of game players is 35 In each game-playing U.S. household there are an average of two gamers present and 51% of U.S. households own a dedicated game console (ESA, 2015). Video games have also inspired yet another developing sector, namely the mass-market consumer software era, which has been exploding rapidly following the original success of an app called Foursquare (Deterding et al., 2011).

This developing phenomenon within the digital media industry acquired the term *Gamification*, which has become increasingly visible and has been widely utilized in recent years. However, the term also remains heavily disputed, particularly in the game studies environment (Deterding et al., 2011). With the effort to clarify its meaning and usage, Deterding et al. (2011) defined gamification as “the use of game design elements in non-game contexts” (p. 9). Since its inception, this definition’s usage has been inconsistent, with continuous discussion of potential alternate definitions among researchers and specialists in the field. For example, Huotari and Hamari (2012) define gamification as “a process of enhancing a service with affordances for gameful experiences in order to support user’s [sic] overall value creation” (p. 19). In different contexts where processes of gamification have been employed, such as in education and business strategies, the term has been defined in more specifically applicable ways (Kapp, 2012; Werbach & Hunter, 2012). In a more recent effort to conceptualise the term gamification, Seaborn and Fels (2015) define it as “the intentional use of game elements for a gameful experience of non-game tasks and contexts” (p. 17). Although some argue that a lack of a clear and consistently used definition perhaps indicates this phenomenon to be a fad, it actually exposes the term’s potential multiplicity (Seaborn & Fels, 2015).

There are four key components in Deterding et al.’s (2011) original definition worth looking at (cf. Sailer et al., 2013) to provide a deeper understanding of the meaning of the terms utilised. First, the term “game”, which traditionally incorporates a goal, rules, a feedback system and voluntary participation. The second term is “element”, which is crucial in differentiating gamification from serious games. Thirdly, the term “design” differentiates game design from the use of game-based technologies. The fourth term in the above definition of gamification is “non-game contexts”, which simply describes that the application of gamification is very broad, but does not include games themselves (Deterding et al., 2011). Deterding et al. (2011) further summarise an expanded explanation of how gamification refers to “the use (rather than the extension) of design (rather than game-based technology or other game-related practices) elements (rather than full-fledged games) characteristic for games (rather than play or playfulness) in non-game contexts (regardless of specific usage intentions, contexts, or media of implementation)” (p. 5).

A limitation of focusing on finding a distinct definition for the term gamification is that related important terminology may not have been considered nor understood by many who apply its concepts. Deterding et al. (2011) specifically address this issue and showcase a systematic approach of other related terminology, defining *gamefulness* as "the experiential and behavioral quality" (p. 3); *gameful interaction* as "artifacts affording that quality" (p.3), and *gameful design* as "designing for gamefulness, typically by using game design elements" (p.3). It is noteworthy here that usually gameful design and gamification will coincide with each other, encompassing the same phenomenal reach (Deterding et al., 2011).

Gameful design is gamification in applied practice. Interestingly, Lee and Doh (2012) assert that gamification focuses on elements fostering extrinsic motivation, whereas gameful design has a focus on intrinsic motivation. As will be demonstrated in the next chapter, this showcases the intricate connection between these terms related to implementation and motivational pull.

Table 2.2: Taxonomy of Game Design Elements

Level	Description	Example
Game interface design patterns	Common, successful interaction design components and design solutions for a known problem in a context, including prototypical implementations	Badge, leader board, level
Game design patterns and mechanics	Commonly reoccurring parts of the design of a game that concern gameplay	Time constraint, limited resources, turns
Game design principles and heuristics	Evaluative guidelines to approach a design problem or analyse a given design solution	Enduring play, clear goals, variety of game styles
Game models	Conceptual models of the components of games or game experience	Mechanics-Dynamics-Aesthetics (MDA); challenge, fantasy, curiosity; game design atoms; Core Elements of the Gaming Experience (CEGE)
Game design methods	Game design-specific practices and processes	Play testing, playcentric design, value conscious game design

Source: Deterding et al., 2011

With an effort to present even further, more granular levels of gamification or gameful design and its related concepts, a taxonomy of game design elements by level of abstraction (Deterding et al., 2011) presents the various levels with descriptions and examples (see Table 2.2). This outline provides a more clearly structured overview of the complex concepts presented within gamification and gameful design at present understanding.

Game design elements are inspired by games and are methods, principles, patterns, objects and models (Seaborn & Fels, 2015). All game design elements serve to generate a motivational pull toward engaging in certain prolonged behaviours. Gamification and gameful design present a potential opportunity for fostering motivation in a variety of contexts (Sailer et al., 2013). Thus, the underpinning notion of exploration of gameful design is to determine what features exactly make the context engaging and motivating. This idea has been coined "situational motivational affordances" (SMAs) (see Chapter 3 for a detailed elaboration of SMAs) (Deterding, 2011) and provides a promising area for further research grounded in evidence-based theory, such as SDT. Based on the developing understanding of the terminology presented in this section, this thesis will employ the term *gameful design* to encapsulate the overarching goal of designing for gamefulness utilizing game design elements.

2.3.2 Gameful Design and Health

In the United States, 215,000,000 hours of gaming occur each day with more than 100 million active gamers (Meloni & Gruener, 2012). This development has not gone unnoticed and many industries have paid close attention to the continually increasing number of gamers. The healthcare industry has taken particular notice of this phenomenon and now gameful design within the health context is becoming a booming business. In fact, gameful design has become an integral component within healthcare and also among health and wellness preventive initiatives making it an essential factor in managing healthcare costs more effectively (Sintek & Pronk, 2013).

In 2004, the Robert Wood Johnson Foundation (RWJF) saw an opportunity to explore the possible connection between the subjects of gaming and health. Gaming (video in particular) had become increasingly popular and the RWJF observed the interesting concept that people seemed to play games for long periods of time, taking in information and translating it into knowledge (Tarini, 2012). RWJF conducted an exploratory investigation in 2004, out of which three conclusions were drawn: (1) the gaming and health community needed to learn about each other and to find a platform on which to come together; (2) the health care system and the health professions were interested in games, but doubted their effectiveness; and (3) there would be power in creating specific games with a purpose to improve health (Tarini, 2012). The "Health Games Research" national program was born in order to address some of the above-mentioned issues. It was followed by the annual "Games for Health Conference" and the peer-reviewed "Games for Health Journal", which addresses this new field of games for health.

Since the launch of the "Games for Health" initiative in 2004/2005, the RWJF has supported innovative research in this area. Results of these research studies are only now beginning to be published. However, despite the increasing interest in the field of games for health, rigorous research is lacking (Kato, 2012). Much of the available research shows evidence of weak study designs, and therefore it is virtually impossible to accurately determine effectiveness (Kato, 2012).

Although this is the case, early emerging findings are in agreement that "… games can motivate and facilitate health behaviour change in a wide range of game genres and game platforms, and for a broad range of target populations on a variety of health topics" (Tarini, 2012, p.8). There is evidence that

gamefully designed applications can positively contribute to desirable health behaviour changes (Mark et al., 2008). Utilising games in connection with health behaviour change interventions provides a positive way to motivate participants intrinsically (Baranowski et al., 2008).

One of the initial challenges within the field of games and health has been that games, designed specifically for a particular health context, can be extremely expensive to produce and are often made for only a small population of people targeted with a planned intervention. The high cost is usually associated with the design complexity and only very large commercial companies are typically in a place to invest in such endeavours (e.g. Nintendo's Wii). Just like the Wii, most of the existing health games employ mechanisms that require the user to have specific devices, such as consoles and systems that have to be set up in particular spaces to be utilised. This lack of convenience, coupled with the high production costs, has presented some significant hurdles for the field of games and health to be researched more effectively. This open gap within the games and health industry has an opportunity to be filled.

As presented in the previous section, the recent emergence of advanced technology has contributed to the birth of the concept of gamification, which may be a promising pathway for the field of health. Within the commercial world, the combination of gamification and health via technology has exploded in recent years and provides an even more promising ground for effective health behaviour change (King et al., 2013; Pereira et al., 2014; Munson et al., 2015; Sola, Couturier & Voyer, 2015).

The development and availability of technological gamified commercial tools, such as web- and mobile-based health applications and activity trackers, are examples of this rapid process. It is challenging to follow and document the existence of all available applications, as many disappear from the market as quickly as they surface. Many of the most popular applications appear to incorporate gamification elements; however, up to 2014, there had yet to be a thorough review of health applications to determine game design elements in relation to behavioural constructs. Examples of such applications include Nike+, FitBit and Zombies, Run!, just to name a few.

Lister et al. (2014) conducted a thorough analysis of 132 health and fitness applications, with a focus on physical activity and diet, utilising the Apple App Store as a platform. This study concluded that including aspects of gameful design within health and fitness applications has become a common practice, showing an association with motivational constructs without evidence of correlation to behavioural triggers (Lister et al., 2014). As projected, further results of this analysis showed no clear evidence in building intentional connections to health behaviour theories, nor did they have any sign of effective gameful design grounded in theoretical foundations.

Not having an industry standard available for the purpose of gamification within health and fitness applications makes it challenging to determine the efficacy of such designs. In fact, Lister et al. (2014) point out that the success of health and fitness applications is currently measured by revenue and not by behavioural outcomes. One key aspect that has been seemingly overlooked is the grounding of gamification for health and fitness in health behaviour theory to determine its effectiveness. Lister et al. (2014) recommend that future research use their findings as a foundational framework with a particular

recommendation for conducting randomised controlled trials in relation to health and fitness application evaluation. Chapter three will introduce a novel approach and framework based on the future research recommendations presented in this section.

Commercial web- and mobile-based health and fitness applications have readily employed gamification. It is a popular strategy with the intent to influence motivation and human behaviour; however, research grounded in theory and data related to efficacy is missing (Tarini, 2012). SDT explains gameplay motivation and physical activity motivation, with the same motives being relevant in both domains, providing a powerful triangular connection of concepts. The following section will provide a more detailed and refined look at current research employing physical activity interventions using gamification principles via computing technology.

2.4 Physical Activity Interventions Using Gameful Design via Computing Technology

2.4.1 Introduction and Foundation

Effective physical activity interventions are needed in response to the rising serious issues related to physical inactivity levels, particularly in the U.S., where physical activity levels decline with age (Loprinzi et al., 2016); thus, employing strategies among sedentary adults in earlier stages of adulthood would be advantageous for earlier intervention before the onset of premature chronic diseases. Based on an evaluation of common barriers to positive physical activity behaviour, it appears that finding pathways to motivate movement promises to be a potential successful strategy, particularly when based on SDT (Teixeira et al., 2012). SDT (Ryan & Deci, 2000) is a well-validated theory for understanding and driving physical activity motivation; thus it seems that an SDT-based intervention to motivate physical activity behaviour is a promising venue of exploration.

Games have long been used and proven to be a great medium to motivate and affect health behaviour, particularly physical activity behaviour. With the rapid advances in technology, the concept of gamification has been introduced and vastly embraced by many different industries. Gamification promises opportunities to produce game-like experiences at a much lower cost with the ability to reach a greater number of users. Further, technology provides different pathways to integrate gamification, namely web-based or mobile-based applications, although not every current available health and fitness application has employed gamification in connection with aiming to change physical activity behaviour. SDT explains gameplay motivation, just as it explains physical activity motivation, showcasing an important connection and thus providing a theoretical foundation.

However, clear guidance on how to employ these strategies within research is scarce and evidence regarding the effectiveness of such approaches is lacking (Kato, 2012). Many commercial web- and mobile-based applications currently exist, many of which attempt to integrate game elements. A detailed review of the current state of this phenomenon will be described in chapter three of this thesis in relation to the specific methodological intervention design. This section focuses on reviewing current available research interventions employing physical activity intervention using gamification strategies via computing technology.

It is important to note that current limited evidence already suggests that Internet-based physical activity interventions are more effective than previous waiting list strategies (Van den Berg, Schoones & Vliet Vlieland, 2007). However, as a result of a systematic review, Van den Berg, Schoones and Vliet Vlieland (2007) conclude that only ten randomised controlled studies met their qualifications, although the initial search prompted 1220 citations. Further, Van den Berg, Schoones and Vliet Vlieland (2007) point out that many of the Internet-based physical activity studies reviewed suffered from methodological weaknesses, which included exclusive reliance on self-report measures, lack of validity and reliability data for physical activity measures and lack of data on follow-up.

Strengths of Internet-based physical activity interventions included: the ability to reach large numbers of individuals for a lower cost, the access to large amounts of information in one place and the choice of time and access (Van den Berg, Schoones & Vliet Vlieland, 2007). Van den Berg, Schoones and Vliet Vlieland (2007) make two key suggestions for future research utilising Internet-based physical activity interventions: first, incorporating more than just one physical activity outcome; and second, employing objective measures rather than relying on self-report measures (Van den Berg, Schoones & Vliet Vlieland 2007). Although these suggestions were drawn from reviews pertaining to only Internet-based physical activity interventions not specifically incorporating gamification principles, they can still apply and inform future research utilising gamefully designed web- and mobile-based physical activity applications and interventions.

The availability of any research studies focusing on web- and/or mobile-based gamefully designed physical activity interventions on this subject is very limited. The following sections present: a) a detailed account of the literature search methods followed by an overview of the selected research studies; b) a critical evaluation and discussion of the present state of research; and c) a discussion of the limitations of the studies presented, closing with recommendations for future research, all of which will frame the development of the research protocol employed for a gamefully designed physical activity intervention.

2.4.2 Literature Search Methods and Results

The purpose of this literature review was to find and evaluate studies specifically focused on exploring associations between gamification and physical activity, thus only studies that represented this intent were included. The definition utilised for gamification in this review was “the use of game design elements in non-game contexts” (Deterding, 2011, p. 9). For the purpose of this review, physical activity is defined as any form of movement carried out by the skeletal muscles that requires energy (Fahey, Insel & Roth, 2011).

The electronic databases searched in this literature review included: Web of Science (n=20), Scopus (n=20), PubMed (n=8), Embase (n=9), APA PsycNET (n=1) and Google Scholar (n=133). The search was limited to the English language without restriction of specific years, except for the search in Google Scholar, where more specific search parameters were employed (see Appendix 2.1).

The key words utilised for this search were: gamification and physical activity. The Boolean string employed in this search was: (gamification AND “physical activity”). Preliminary experimental word searches resulted in the decision to specifically focus only on literature that focused particularly on these two terms in association. Since this area of research is rather new, it was important to allow a simple method in order to yield any relevant results.

This review followed the recommendations in the reporting of systematic reviews according to the PRISMA flow and checklist (Moher et al., 2009) (see Appendix 2.2). The following inclusion criteria guided the literature review: (1) peer-reviewed; (2) full papers; (3) a focus on physical activity behaviour employing some form of gamification principles; and (4) the application of some form of computing technology. Exclusion criteria included: (1) a lack of integration of gamification principles in relation to the intervention; (2) a lack of specific focus on physical activity; (3) a primary focus on the medical context/medical condition; (4) theoretical/conceptual papers; (5) a specific focus on exergames/videogames; (6) a specific focus on children/educational settings; and (7) a primary focus on activity trackers, rather than on computing technology (e.g., web-based or mobile-based).

Due to the needed adapted search parameters with Google Scholar, two separate sets of searches were conducted with search one focusing on the electronic databases mentioned above and search two focusing on Google Scholar only. The initial search one identified 58 papers. After removing duplicates, 38 papers remained. These were assessed for eligibility based on the criteria outlined above reviewing the title and abstract. Four final studies remained eligible and were selected for review in this section.

Search two (Google Scholar) demanded a more specific search approach. The initial search was limited to the years 2012 to 2016 and yielded a total of 1,520 papers. Thus, the search was refined employing the following Boolean string: (gamification AND “physical activity” AND Internet AND adults). This refined search produced a total of 512 papers. Another adaptation was undertaken, namely reducing the eligible inclusion years to 2016 only, which then resulted in 67 papers. After applying the criteria outlined above based on the title and abstract, six studies remained eligible for review. After careful assessment of all six studies, it was determined that none met the inclusion criteria for review (see Appendix 2.1).

Four studies aiming to increase physical activity in association with some form of gamification principles were selected for this review (Table 2.3). This search result verifies the need for further studies with a particular focus on the subject of interest in this thesis demonstrated by the current dearth of available eligible papers.

As displayed in Table 2.4, the four studies employed various study designs with randomised controlled trials being the primary choice. Data was predominantly quantitative, being collected by an array of objective and subjective measures, such as accelerometers, biometrics, questionnaires and self-report options. One of the four studies utilised interviews to obtain additional qualitative data.

Table 2.3: Selected Studies for Review

#	Author(s)	Publication Year	Delivery Mode of Intervention
1	Ahola et al.	2013	Web-based
2	Gotsis et al.	2013	Web-based
3	Thorsteinsen et al.	2014	Web- and mobile-based
4	Zuckerman & Gal-Oz	2014	Mobile-based

Sample sizes at the beginning of the studies varied from 31 to 1280 and represented various ages from 18 to 88 years among the adult population. Every study employed computing technology modalities, such as web-based or mobile-based delivery systems. Gamification elements included points, rewards, virtual characters, virtual locations, the collection of virtual items, the ability to spend earned virtual points, virtual wellness activities, social interaction, challenges and the exchange of virtual gifts.

Table 2.4: Methods and Data Collection

STUDIES	1	2	3	4
Sample	N = 1280	N = 87	N = 31	Study 1: N = 40 Study 2: N = 59
Duration	6 months	13 weeks	3 months	Experiment Survey RCT (modified)
Type	RCT	Field experiment (randomised crossover design)	RCT	Experiment Survey RCT (modified)
Measures	Acc. Quest. Biometrics Fitness levels	Self-report Biometric	Self-report Quest.	Quest. Interviews

**RCT = Randomised Controlled Trial; *Acc. = Accelerometer; *Quest. = Questionnaires*

Study one utilised the Transtheoretical Model of Behaviour Change (TTM) as a theoretical foundation to frame the study. Studies two and three did not employ any theoretical framework. Study four employed Social Comparison as its theory-base for research. None of the present studies utilised SDT, although, as outlined in previous sections of this chapter, SDT has been evidenced for successful theoretical framing for research related to physical activity and gamification.

Main findings of the review of the selected studies suggest an increase in physical activity frequency and time indicating a positive effect of gamification in three of the four studies (see Table 2.5). Study one has not actually published the results; thus, the impact is unknown at this time.

Table 2.5: Results

Studies	Results
1	N/A; have not yet been published
2	⇒ increase in exercise frequency from baseline to FU 1 and FU 2
3	⇒ increase in PA minutes at week 5 and 9 (significant) and week 12 (not significant) in test group
4	⇒ increased walking time (statistically significant) in quantified version ⇒ the two gamified versions were only as effective as the quantified version for promoting walking

2.4.3 Detailed Review

This section will provide a short, detailed summary of each of the studies selected for review, in order to provide a deeper insight into the study design and context prior to a critical discussion and analysis in the following section.

Study 1: Ahola et al. (2013)

A randomised controlled trial, aiming to examine the effectiveness of gamification on physical activity in young men in the military in Finland, began in the fall of 2013, and its results have not been published yet. This study is based on an authentically designed interactive gamified activation method utilising peer networks and participation with the aims to evaluate the effectiveness of gamified activation as it relates to physical, mental and social health (Ahola et al., 2013). The purpose of the use of gamification principles in this study is to increase user engagement and participation among young men in the military. The intervention group is exposed to the gamified web-based activation method, whereas the control group just continues life as usual with no exposure to any type of gamified tool or method. The main aim of this study is the provision of evidence-based knowledge for the improvement of health and wellbeing for young men.

The multidisciplinary approach to this study has two objectives: (1) assessing the effectiveness of the gamified activation method; and (2) assessing the effectiveness of the gamified activation on physical, mental and social health (Ahola et al., 2013). Effectiveness here is defined as higher levels of physical activity and fitness, a lower percentage of obesity and better self-determined and measured health (Ahola et al., 2013). The study protocol is designed to incorporate quantitative and qualitative methods, including biometric measurements, physical fitness measurements, ethnographic interviews and objective physical activity measurement via an accelerometer. The intervention is planned for a six-month period, with pre- and post-data collection. This study protocol indicates that the subjects will be followed throughout their military service, post-intervention, for a period of 18–30 months depending on their length of service. Fitness tests will again be conducted at the end of their service to provide data on long-term effectiveness of the intervention (Ahola et al., 2013).

This web-based gamified physical activity application is designed to track, monitor and reward exercise behaviour. It includes the following game mechanics: (1) virtual coach (avatar); (2) rewards; (3) social networking between peers; (4) feedback; (5) social counselling on healthful behaviours; (6) exercise instruction; (7) goal setting; and (8) customised information for

players based on their readiness for change (Ahola et al., 2013). The theoretical framework utilised for the readiness for change evaluation is Prochaska's Transtheoretical Model of behaviour change.

The main outcome measure for this research study is the objectively measured physical activity via wrist-worn accelerometer (Polar Active), which will indicate frequency and intensity of physical activity. The type of activity will be measured utilizing triaxial accelerometry via smartphone software. The second outcome measure is the proportion of overweight and obese young men (Ahola et al., 2013).

Study 2: Gotsis et al. (2013)
In a recent field experiment (Gotsis et al., 2013), a web-based diary (Wellness Partners) was pilot-tested utilising a randomised crossover design. One of the two test groups received exposure to one "diary" version with limited social networking features and the other test group had access to a "diary + game" version, which contained social gaming features, for the duration of the intervention. The four aspects included in both versions of the web-based diary were: "(1) posting updates of physical activities or setbacks, (2) sending private messages, (3) reviewing complete history of updates posted by egos and their alters, and (4) viewing display of a tag cloud of posted physical activities by all members in the egocentric network" (Gotsis et al., 2013, p. 4). The diary with advanced gaming features had many additional options such as: points, rewards, virtual characters, virtual locations, the collection of virtual items, the ability to spend earned virtual points, including virtual wellness activities, and the exchange of virtual gifts. There is no indication that the development of this web-based intervention was based on any particular theoretical framework.

The objectives of this project were to evaluate the process of this intervention design, evaluate its implementation and research the impact of the gaming features on participants' levels of physical activity. This study was conducted in a workplace setting and therefore targeted adults between the ages of 17–88, utilising a unique strategy by having the voluntary participants (egos) of this study enrol additional participants (alters) as part of their team. The measurement tool for physical activity levels in this study was self-reporting, without any additional objective measurement features.

Self-reported physical activity frequency levels increased in both groups; however, the increase in the "diary + game" group was greater from baseline to first follow-up (three months) and to second follow-up (six months) than that of the "diary only" group. Furthermore, there was an observed decrease in BMI for the "diary + game" group as well as a detectable trend towards decreases in body fat percentage though not enough to be statistically significant.

Study 3: Thorsteinsen, Vittersø & Svendsen (2014)
Thorsteinsen, Vittersø and Svendsen (2014) embarked on an experimental pilot study to evaluate the effectiveness of an Internet- and app-based physical activity intervention ("Lifestyle Tool"). This intervention included gamification components such as points, social contracts, competition and virtual rewards. Beyond these components, this intervention included interactivity, an activity planner, progress monitoring and an SMS text system to provide feedback.

Healthy adults, ages 35–73, were recruited through local newspaper ads in Norway and were randomised into an intervention and a control group for the purpose of this pilot experiment. The final sample size was 21, with 12 participants in the intervention group and nine in the control group. Thorsteinsen, Vittersø and Svendsen (2014) note that one participant in the control group demonstrated extremely high levels of physical activity, thus he was removed from the analyses, dropping the total sample size to 20. The study was three months in duration. The design of the entire intervention is complex and used multiple pathways beyond gameful design only.

"Lifestyle Tool" consisted of a rule-based website designed to assist with planning and monitoring physical activity behaviour. Upon first login, participants were asked to complete a questionnaire (BREQ-2), which assesses levels of motivation for physical activity. Next, participants were prompted to plan their physical activity schedule, which the system then utilised to generate regular graphs to reflect on actual physical activity versus planned physical activity. Further, the system provided educational information on recommended guidelines for physical activity. The SMS message system in this study delivered regular messages informing participants about the benefits of physical activity and the dangers of physical inactivity. In addition, the SMS system provided practical tips. One unique feature was the personalisation and adaption of the SMS system, for example by referring to the participant by their first name. Both groups utilised a daily physical activity report system in four registration weeks throughout the three-month study.

Results of this study showed no significant effect between the physical activity levels comparing the two groups. However, analyses showed that the intervention group had significantly more minutes of physical activity in two of the 12 weeks (week five and nine) (Thorsteinsen, Vittersø & Svendsen, 2014). Further, an increase in physical activity intensity was discovered in the intervention group in week five.

Thorsteinsen, Vittersø and Svendsen (2014) observed that all participants in the intervention group chose to utilise the online physical activity planner, all of them chose to join one or more competitions and the majority of participants chose to join at least one social contract within the application. Initial effects of intervention group participants reporting higher levels of physical activity in week five of this study were sustained through week nine; however, thereafter, a drop-off in effect was noticed.

Study 4: Zuckerman & Gal-Oz (2014)

In a more recent attempt to research the gamification components of virtual rewards and social comparison, with a connection to physical activity behaviour via an app-based approach, Zuckerman and Gal-Oz (2014) embarked on a new type of experiment. First, a new research prototype was developed, called "StepByStep", which aimed to promote routine walking (without any additional options for measuring other types of physical activity). This new app was made available for Android-based mobile devices only and its effectiveness was measured via two field studies. "StepByStep" was designed to function as an accelerometer-based device delivered through an app on the phone, which is a very non-invasive approach, as it does not require participants to wear additional devices for the purpose of measuring physical activity.

The first field experiment in this study utilised a quantified version of the "StepByStep" application providing the following measurements: time walked, daily goal setting and real-time feedback regarding progress towards the goal. This version did not employ the gameful design elements of virtual rewards or social comparison. Results showed that this version facilitated a reflection process of the participant on the activity level. Further, results showed significantly increased walking time from baseline data (Zuckerman & Gal-Oz, 2014). Field experiment two used a gamefully designed version of "StepByStep" utilising specifically virtual rewards and social comparison. Comparison of results from both field experiments showed that the latter was only as effective as the first version (Zuckerman & Gal-Oz, 2014); thus, no significant difference was detected.

The field experiments were followed up with questionnaires and interviews given to the participants on various aspects of the experience. A significant observation of the data results from the questionnaires included the most commonly noted advantage of the application by participants in both groups, which was the increased awareness of walking each day. Zuckerman and Gal-Oz (2014) do not provide additional information as to what may have contributed specifically to this heightened awareness. The group exposed to virtual rewards overall concluded that the point system was meaningless to them. The leader boards, employing social comparison, were perceived differently based on interpersonal differences and overall the application was perceived to be ineffective as reported by the participants (Zuckerman & Gal-Oz, 2014).

2.4.4 Discussion

Physical activity behaviour has been identified as a key component contributing to better health, improving overall wellbeing and assisting in the prevention of the development of chronic disease. With the rise of adults becoming increasingly less physically active, innovative pathways to change that trend are essential to prevent the expansion of the physical inactivity epidemic. Gamification has been identified to foster engagement and motivation in a variety of contexts and has recently been of increasing interest in relation to physical activity behaviour, particularly via technological computing pathways providing the ability to reach a greater volume of people.

As a clear definition of gamification is continuously emerging, so is the understanding of gamification elements. Currently, there is no agreed-upon taxonomy of specific gamification elements for the physical activity context. However, there are most common gamification elements that have been identified with an assumption that they must have an impact on motivation and behaviour, although research is lacking evidence for efficacy values (Kato, 2012).

The four studies identified in the literature review all employed some form of gamified intervention to motivate physical activity behaviour. Out of the four studies, three reported the observation of positive results in relation to increased physical activity. While this trend was observed, and in some of the studies actual statistical significance was detected, outcomes may not be sustained over a longer period of time (Thorsteinsen, Vittersø & Svendsen, 2014). Further, it is unclear whether all types of gamified elements motivate users to engage in physical activity (Spillers & Asimakopoulos, 2014).

Virtual rewards are a common gamification element and occur in Vittersø and Svendsen in different formats, but are typically digital incentives awarded to the participant of a gamefully designed application as a result of engaging in some type of desired behaviour. The most frequently used formats of virtual rewards are points, badges or virtual goods. Interestingly, these features can actually function in multiple ways beyond their initial mode of acting as incentives. They can provide instruction, encourage participants to set goals, help participants develop reputations and determine their status, give affirmation and provide group identification (Antin & Churchill, 2011).

Participants in study four reacted very differently to virtual rewards; some did not even understand them or utilise them (Zuckerman and Gal-Oz, 2014). Zuckerman and Gal-Oz explain that researching the game element of virtual rewards is an important endeavour, as previous research suggests that external rewards can diminish intrinsic motivation (Deci, Koestner & Ryan, 2001). Deterding (2011), however, notes that it is a voluntary act to participate in a gamefully designed application or game, which is technically free of consequences. Voluntary participation enhances perceived autonomy, which SDT asserts contributes to increased intrinsic motivation (Deci, Koestner & Ryan, 2001). The use of points (=virtual rewards) contributed to increased physical activity in Thorsteinsen, Vittersø and Svendsen's (2014) research; however, it is important to note while the increase was observed initially, a decline in physical activity was reported over the longer term.

Social comparison usually entails a visual comparison of abilities and achievements to others. It employs the mechanism of competition and is frequently used in physical activity applications (Zuckerman & Gal-Oz, 2014). Further, however, social comparison can also employ mechanisms of social support and encouragement that in turn would enhance the feeling of relatedness, which according to SDT contributes to intrinsic motivation.

Interestingly, intervention effectiveness related specifically to social gaming features was observed among all different age groups, different ethnicities, educational backgrounds and genders (Gotsis et al., 2013); however, since evaluation measures were limited to quantitative data, deeper insight into the possibilities for efficacy are unknown. Zuckerman and Gal-Oz (2014) employed qualitative measures via interviews, which revealed that responses and attitudes toward specific game elements are highly individualised. For example, while one person is positively motivated by points, another is positively influenced by leader boards, and yet another is negatively affected by them. This diversity of reactions leads to the concept of meaning, namely that participants must see the value and meaningful application in relation to the behaviour the intervention aims to impact. Creating contextualised, meaningful gamified situations for users could hold the key to pinpointing more specific reasons for effectiveness (Nicholson, 2012).

Zuckerman and Gal-Oz (2014) provide further evidence through their conclusions that there is merit in developing and exploring the concept of situated motivational affordances (Deterding et al., 2011) in future research. This idea may provide important contributions to the development of meaningful gamification frameworks linked with particular existing frameworks in specific domains, such as physical activity behaviour.

2.4.4.1 Limitations

There are several limitations that prohibit a definite conclusion regarding the effectiveness of gamification to positively impact physical activity behaviour. Firstly, none of the studies employed a sound theoretical foundation related to human motivation, such as SDT. In fact, two out of the four studies did not employ any type of theoretical framework upon which the interventions were built; thus, methodological robustness is questionable. Further, the reviewed studies relied heavily on quantitative data collection, which lacks further insight into the processes and reasons why participants behaved the way they did throughout the intervention.

Ahola et al. (2013) is the only study that employed a long-term evaluation approach to data collection and analysis (with results pending), whereas the other three studies focused on short-term effectiveness. This limits the understanding of gamification effects on physical activity over a longer period of time, which is a vital component in sustainable behavioural change. Since all studies reflected a positive trend related to increase in physical activity frequency and time over the short-term, a novelty effect of gamification could be an explanation, leaving in question the effectiveness over a long-term period.

None of the studies provided a clear rationale or theoretical framework showcasing the choice of game elements incorporated in the interventions. Thus, it appears that the study design in relation to gamification was random without a clear plan or direction to evaluate the effectiveness of the chosen game elements. Research is needed to provide insight into the unique contribution that gamification could make in relation to physical activity behaviour change, yet theoretical frameworks are lacking for specific subject areas, making this a novel area of research.

Another definite limitation observed in these studies is the use of self-report data in all studies via direct self-report tracking or questionnaires. Self-reporting is a subjective measure and the data reported may not be as accurate as it would have been utilising objective measurements.

Gotsis et al. (2013) noted that there were several technical problems through the course of the intervention, which included a persistent software bug preventing some participants from logging their activities onto the Wellness Partners website. On one occasion, automatic email messages were not sent out. Due to an initially undetected error, a few of the ego-network groups were not switched over after the first follow-up period and therefore had to be excluded from the reported data. The game design feature of points earned had to be modified after a few weeks of the start of the intervention, which impacted the participants who began the study early on. Gotsis et al. (2013) further reported that they did not anticipate participants logging in to the website more than once per day, which resulted in the earned points discrepancy.

Thorsteinsen, Vittersø and Svendsen (2014) had a very low sample size, which presented difficulty during analysis in determining which components of their intervention may have contributed to the increase in physical activity. Another limitation of Thorsteinsen, Vittersø and Svendsen (2014) includes the recruiting process. Participants responded to an ad, which assumes that these participants already had a higher motivation to increase physical activity or make changes of some sort. In addition, the study commenced in January,

which is usually a time of year in which more individuals are motivated to make changes related to their health behaviours.

Zuckerman and Gal-Oz (2014) identify several limitations of their approach to their research study. First, only two specific game elements were focused on rather than a greater variety. Thus, it is possible that additional game elements in combination could have yielded greater effectiveness. Second, the concept of situational usage and meaning of game elements must be considered when evaluating the efficacy of gameful design, which is referred to as situated motivational affordances (see Chapter 3 for a detailed exploration of this concept). Zuckerman and Gal-Oz (2014) note that it is vital to evaluate this important component in future research. Another limitation identified was the focus of only one type of physical activity in these field experiments. Further, participants only utilised the intervention for a period of no more than two weeks, which does not reveal much about its effectiveness in relation to longer-term adherence to desired behaviours, in this case walking.

2.4.4.2 Future Research

Future intervention research evaluating the effectiveness of gamification on physical activity behaviour should focus on and incorporate the following specific components; researchers should (1) ground the research in an evidence-based theoretical framework; (2) design a specific applicable methodological approach that is robust and corresponds specifically with gamification in the context of physical activity behaviour; (3) address adequate enrolment for a fully powered study and find pathways to minimize attrition; (4) employ randomised controlled trials with control and intervention groups to determine what specifically gamification adds to the context; (5) use objective measures for more accurate results; and (6) explore situated motivational affordances, an approach which considers specific game elements in particular contexts and situations related to a specific domain.

In addition to these main principles, there are other important aspects that should be considered in future research. Firstly, based on the developments in technology, it is advisable to have mobile access to any web-based intervention for ease of use. Further, choosing a community setting with a population sample rather than a workplace setting, for example, would be better for greater generalisability.

Thorsteinsen, Vittersø and Svendsen (2014) note that future research should focus on identifying which gamefully designed components are most effective. The usage of technology should continually be explored, especially in light of new modes and mechanisms emerging rapidly, which allow participants to be reached where they are (Thorsteinsen, Vittersø and Svendsen, 2014). Zuckerman and Gal-Oz (2014) recommend that future research focus on systematic evaluations of all elements utilised (quantified and gamefully designed) within the context of situated motivational affordances.

2.4.4.3 Conclusions

This review of specific literature evaluating existing research linking gamification with physical activity behaviour provides promising evidence that positive associations exist worthy of further exploration. Further, the lack of application of evidence-based research or the use of weak methodologies provide an avenue of future development of more rigorous research in the field. If future research recommendations, as outlined above, were employed,

a greater understanding of specific aspects of gamification in relation to physical activity could be detected, adding value to the existing body of knowledge. The findings of the concept of situated motivational affordances show promise for further detailed development in the field of physical activity behaviour change.

2.5: Summary

Physical activity behaviour has been identified as an important and positive contributor to overall good health, wellbeing and the prevention of chronic disease. Movement of the human body provides a multiplicity of wellness benefits in multiple dimensions, even as lifestyle medicine to reverse many ailments. Based on current data, physical activity levels have decreased significantly, while sedentary behaviour has increased among all age groups, particularly in the U.S. Physical inactivity is an independent risk factor for early death and ranks number four among all health behaviours contributing to lower longevity and lesser quality of life. Thus, in order to address and reverse the current physical inactivity epidemic, it is essential that continued research be conducted to explore alternative ways to motivate and engage people to move more and sit less.

Among many reported barriers to physical activity, motivation to be physically active ranks among the highest. Motivation is a known effective tool to increase physical activity levels as evidenced by previous research grounded in SDT. SDT has shown great promise in connection with physical activity and asserts that the more motivation for a particular behaviour or task is internalised, the more likely it is for someone to engage in that behaviour long-term (Ryan & Deci, 2000). Validated measures, such as the Behavioural Regulations for Exercise Questionnaire (BREQ-2), provide valuable tools to research intrinsic motivation in connection to physical activity behaviour.

Gamification is a recently emerging phenomenon, derived from the familiar, long-existing concept of game play, that shows promise to provide motivation for behaviours in various contexts. Although a clear definition of gamification has been a continuous work in progress amongst researchers in this field, the most frequently used and referenced definition is “the use of game design elements in non-game contexts” (Deterding et al., 2011, p.9). Gameful design can be a powerful toolkit (Werbach & Hunter, 2012) when game design techniques are appropriately understood, applied and grounded in a proper theoretical framework for motivation. Gamification has been successfully linked to SDT in showing a link to motivating behaviour, thus providing a potential platform for connection with physical activity behaviour. In fact, current research shows that SDT is the dominant theoretical framework utilised within the subject of gamification.

The usage of commercial technological tools, delivered via web- and mobile-based applications, has skyrocketed, particularly among young and middle-aged generations. According to the U.S. Census Bureau Data (File, 2013), young professionals (ages 25 to 44) seem to represent the age group that has a high usage of the Internet and smartphones, as well as being engaged at the highest level in many forms of gaming (ages 30 to 45). Gamefully designed physical activity applications using computing technology have grown rapidly over recent years, commercially and within research, and have shown positive trends in motivating physical activity behaviour. Gameful design may be the key to increasing motivation and adherence to physical activity and fitness (Recio, 2012).

The review of relevant research literature suggests that there is a potential for applying gameful design techniques to non-game physical activity contexts; however, rigorous research to determine the effectiveness of gamification motivating physical activity behaviour is scarce and lacking (Kato, 2012). A key issue to improving the evidence of the effectiveness of physical activity interventions is the current deficiency of theory usage, which informs psychological and behavioural processes (Roberts and Treasure, 2012).

Poor research design and non-robust methodologies are largely to blame for limited conclusions. Available research studies show a lack of adherence to professional standards and guidelines (Lister et al., 2014). However, current research knowledge on gameful design does validate the idea that user engagement and motivation are positively impacted in meaningful, theory-grounded gameful design (Deterding et al., 2011).

Physical activity measures should not rely solely on subjective self-reported data, but employ objective and validated methods for obtaining more accurate data, such as accelerometry systems. Research so far is not conclusive as to how long gamefully designed research interventions change behaviour; however, there is a definitive consensus for the need to observe the impact of these types of interventions longer-term to determine adherence.

Additionally, the literature review exhibited the need to conduct qualitative analysis, particularly to evaluate and understand the relationships between specific game elements in combination with engagement and motivation for particular behaviours, such as physical activity. More insight into these processes is needed to obtain a deeper understanding and consensus of efficacy.

Typical game elements utilised frequently include: points, badges, leader boards, performance graphs, quests, meaningful stories, avatars and profile development (Sailer et al., 2013). Werbach and Hunter (2012) approach the concept of game elements from a broader perspective, categorising them as game dynamics, game mechanics and game components. Kapp (2012) describes game elements in a more traditional sense, including things like reward structures, levels, competition, time frames and rules. Sailer et al. (2013) assert that the efficacy of gameful design may be dependent on the audience, the environment and the context. Thus, simply taking a random game element, such as points or rewards, and applying it to a non-game context may have implications that are contrary to the intentions. Currently, there is no guidance on how to choose or design gamified interventions in a theory-based manner. There is an on-going discussion among researchers and specialists in the field of gameful design regarding what constitutes meaningful and effective game elements, creating the need to develop specific frameworks for particular domains, such as physical activity.

Further, there is a lack of integrating underpinning motivational and health behaviour theories in the research design connected with gamification principles. If such were employed, evidence-based, theory-grounded methodologies could increase the potential for determining efficacy of gamification in association with physical activity immensely. In summary, a gamefully designed physical activity intervention, informed by SDT and delivered via modern technology, could produce powerful, innovative pathways for increasing motivation for physical activity, decreasing sedentary behaviour and increasing physical activity levels.

CHAPTER 3: STUDY 1 – THEORETICAL FRAMEWORK DESIGN

3.1 Introduction

The main aim of this *Theoretical Framework Design Study (Study 1)* is to design a novel theory-informed framework to inform the selection of an intervention to be applied to the *Intervention Implementation Example Case Study (Study 2)*. To develop a theory-grounded framework to inform a comprehensive intervention protocol, the following objectives were formulated: (1) to review advanced theoretical concepts of motivation connected to gameful design; (2) to review theoretical principles of health behaviour change techniques (BCTs) and possible connections to physical activity and computing technology; (3) to design a theoretical framework for gameful design *and* (4) to apply the newly designed theoretical framework to select an intervention application for the use in *Study 2,* serving as an example case study.

The previous chapter employed the first step of the IM model, namely assessing the health problem (physical inactivity), the population (sedentary adults) and one of the main determinants (lack of motivation for physical activity behaviour). The IM model allows an iterative application to fit a variety of contexts; thus, *Study 1* employed steps three and four of the implementation process of IM. Step three entails the establishment of the connection between theory and practice, involving choosing program methods and selecting strategies. Step four of IM focuses on the program production (i.e., intervention) in relation to development and design, which in this study protocol ultimately resulted in the selection of the most appropriate web- and app-based gamefully designed physical activity application for *the Intervention Example Case Study (Study 2).* Based on the fact that a suitable theoretical framework and methodology was not readily available to inform the second step of IM, steps three and four must precede this step to first determine theory-informed approaches. Specific change objectives are articulated as part of *Study 2* (Chapter 4). The study design for *Study 1* follows a three-stage model (see Figure 3.1).

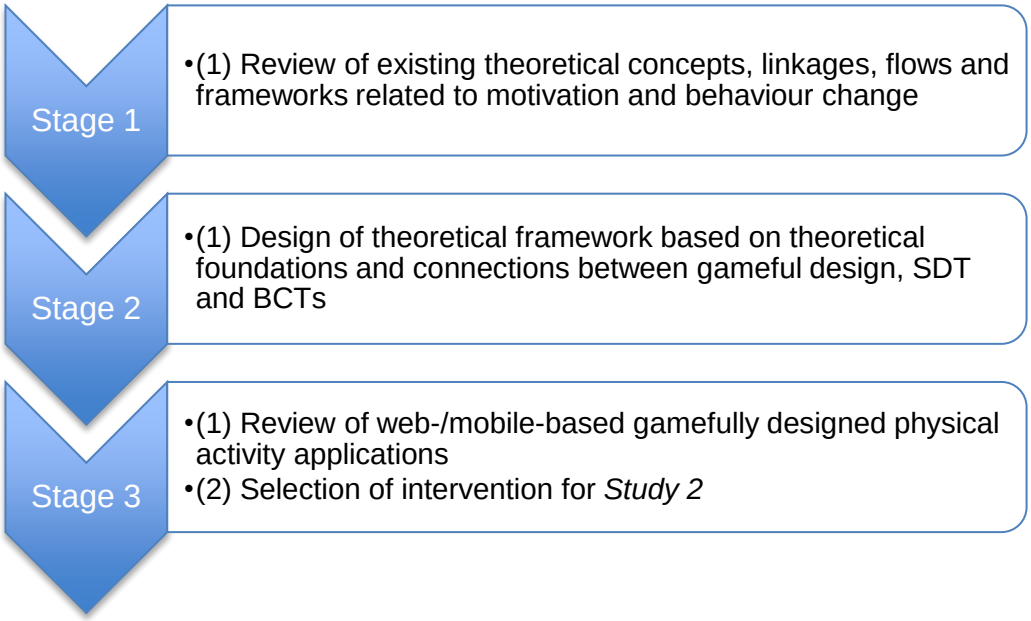


Figure 3.1: Study 1 Research Process Model

Stage one of this model entailed the review of existing theoretical concepts and frameworks related to motivation and behaviour change. The particular focus was on SDT, gameful design and BCTs. Stage two of the model entailed the development of a theoretical framework, based on the theoretical foundations and bases reviewed, to inform the selection of an intervention for *Study 2*. Stage three constituted the application of the newly established theoretical framework from stage two of this model, including the review of intervention options (web-/mobile-based physical activity applications) and the selection of intervention applications.

3.2 Research Process Model – Stage 1

3.2.1 Advanced Theoretical Concepts of Motivation and Gameful Design

Current research supports the notion that well-designed games foster engagement and enjoyment through the strong experiences of autonomy, competence and relatedness, the basic need satisfaction (Przybylski, Rigby & Ryan, 2010; Tamborini et al., 2011; Mekler et al., 2014), thus indicating that gameful design promotes internalised forms of motivation. There is a preliminary consensus among researchers that the ideas of extrinsic and intrinsic motivation, as outlined in SDT, provide a promising theoretical foundation for the development of gameful design research (Witt, Scheiner & Robra-Bissantz 2011; Thom, Millen & DiMicco, 2012; Gnauk, Dannecker & Hahmann, 2012).

SDT centres around basic need satisfaction tied to the three basic psychological needs of autonomy, competence and relatedness (see Section 2.2.2) and has been successfully linked with physical activity behaviour (see Section 2.2.3). Deterding (2016) asserts that SDT is a promising foundational theory that can provide the opportunity to measure the impact of various contexts for motivation linked to game play.

Thus far, however, most available intervention research, aiming to determine the effectiveness of gameful design with particular motivational and behavioural outcomes, has failed to be grounded in theory overall and also has frequently not defined the terminology related to gameful design within the studies (Seaborn & Fels, 2015). In a recent, most comprehensive survey of gameful design, Seaborn and Fels (2015) recommend that future research empirically explore theory with a focus on validating the application of theory to practice.

Schlagenhaufer and Amberg (2014) identified five psychology theories employed within the context of gameful design as a result of a review of information systems literature focused on the integrated creation of motivation, behaviour and gameful design: (1) Theory of Flow; (2) Self-Determination Theory; (3) Self-Efficacy Theory; (4) Theory of Planned Behaviour; and (5) Uses and Gratifications Theory. Out of these five theories, SDT was used in four of the nine studies reviewed, representing the highest usage of all the other theories utilised (Schlagenhaufer & Amberg, 2014); however, the overall utilisation of theoretical foundations is very low among existing research in general (Seaborn & Fels, 2015). This most recent review (Schlagenhaufer & Amberg, 2014) showcases that SDT presents a promising theoretical foundation for gameful design research with greater potential than other currently available theories.

Based on a comprehensive research approach including four studies (Ryan, Rigby, Przybylski, 2006) investigating motivation for computer game play and applying SDT, Ryan, Rigby and Przybylski (2006), leading researchers in human motivation and gameful design, conclude that SDT provides a valuable opportunity as a theoretical foundation for gamefully designed virtual worlds. They assert that people are attracted to video games because their innate needs for autonomy, competence and relatedness are met, as SDT outlines. Within a video game setting, the player can choose what game activity they would like to engage with, and in many situations the player chooses in which way to perform particular activities within the game, providing the player with autonomy. If the player is able to effectively execute the actions within the game, he or she may experience a certain level of competence (Ryan, Rigby & Przybylski, 2006). Further, Ryan, Rigby and Przybylski (2006) indicate that video games provide many opportunities to connect with other players, either virtually or realistically, giving the player a feeling of relatedness. All four studies (Ryan, Rigby & Przybylski, 2006) resulted in the support of the notion that gamefully designed virtual environments can foster autonomy, competence and relatedness, resulting in increased motivation and creating a particular pull of the gameful design, reflecting the effectiveness of SDT in the context of gameful design.

The review of existing research in Chapter 2 revealed that although SDT has been clearly positioned as the key theory within gameful design literature (Schlagenhaufer & Amberg, 2014; Seaborn & Fels, 2015; Deterding, 2016) as described above, that current available gamefully designed physical activity applications have not employed SDT, nor have they employed any theoretical bases. Further, the detailed discussion in Chapter 2 revealed that SDT is a useful theoretical framework for understanding the motivation specifically for physical activity (see Section 2.2.3).

The evidence of gameful design fostering enjoyment and engagement (Ryan, Rigby, Przybylski, 2006) has showcased that the assertions of SDT match. Thus, Rigby and Ryan (2007) developed a model for the motivational pull of game design based on SDT referred to as the “Player Experience of Need Satisfaction” (PENS) model, which has been validated (Peng et al., 2012). It is one example of a model that also encompasses an evaluation tool for applied theory within gameful design. This model “identifies and measures those elements of the player experience that are most deeply satisfying and valued” (Rigby & Ryan, 2007, p. 2).

PENS is not only useful for the measurement of outcomes, but also measures the causal elements that make up a satisfying experience. PENS assumes that the three basic psychological needs are differently satisfied by three aspects of gameplay: game mechanics (game controls, action elements, etc.), gameplay (the-moment-to-moment activity of the player) and player narrative (player’s character, game scores, online forums, etc.) (Rigby & Ryan, 2007). The success of the game and the experience of the player are largely dependent on the satisfaction of the basic psychological needs.

A sense of efficacy and of mastering a situation provide a feeling of competence. In this regard, it is important that game mechanics are designed in a way that they do not become a barrier and prevent people from feeling competent: game mechanics are the gateway or access to the game that should be easily grasped and overcome. Maximising competence-need satisfaction in gameplay includes giving players a chance to put their mastery

into action, a leg-up to provide a feeling of greater importance, consistent positive feedback during gameplay and a feeling of continued success rather than failure (Rigby & Ryan, 2007).

Moving on to autonomy, players must feel that they have a choice in the decisions they make and actions they take. The feeling of having control of a situation provides energy and motivation. Forced choices can be demotivating, and that applies to the game context. Instead, game designers need to maximise the players' "opportunities for action": the range of actions afforded by interactive objects available to the player relative to the player's goals. PENS also posits that autonomy is supported by choice of the player as to who they will be in the game.

Finally, relatedness in the game context is connected to the interaction with other players or, in single-player games, to the computer-generated figures that interact with one's avatar. Other people or players can provide meaningful goals, communication and support (Rigby & Ryan, 2007).

Based on the evidence presented in this section, SDT is being proposed as the most promising theoretical foundation at the present time to be applied to researching constructs and concepts in relation to gamification. However, SDT alone is not granular enough to suggest specific program methods or behaviour change techniques for the purpose of selecting an effective intervention as a case example, as aimed for in this study. In addition, at present, there is not a good taxonomy of gameful design program methods linked with behaviour change techniques grounded in SDT available for research or practice implementation within the context of physical activity promotion.

Some attempts have been made to develop standardized approaches integrating SDT and gameful design; however, there has been a lack of transparent theory-based design approaches prohibiting the actual connection between theory and practice. Aparicio et al. (2012) designed a framework linking basic frequently used game elements to the SDT constructs of autonomy, competence and relatedness; however, no research utilising this framework has been published at this time, and a clear linkage of concepts for the purpose of health behaviour change is missing. Thus, a more advanced exploration of theoretical concepts is necessary in order to move towards the establishment of a rigorous research intervention that can evaluate the effectiveness of such notions.

In 2008, Zhang introduced the concept of *motivational affordances* in relation to information and communication technology (ICT). Zhang explores issues related to motivation and states that if ICT designs are made in a way to involve the motivational needs that people have, there would be a greater level of interest, engagement and enjoyment. This will leave people wanting more, having an attraction to a particular ICT design. Zhang defines motivational affordances as comprising "… the properties of an object that determine whether and how it can support one's motivational needs" (2008, p.145).

In 2011, Sebastian Deterding built on Zhang's idea by introducing the *situated motivational affordances* (SMAs) of game elements conceptual model. Deterding (2011) asserts that utilising the concept of motivational affordances would provide a systematic approach for studying the more granular levels of game elements, and he argues that within gameful design these elements must be conceptualised as necessarily situated (Deterding, 2011). Furthermore, he defines this concept of

SMAs as describing "… the opportunities to satisfy motivational needs provided by the relation between the features of an artefact and the abilities of a subject in a given situation, comprising of the situation itself (situational affordances) and the artefact in its situation-specific meaning and use (artefactual affordances)" (Deterding, 2011, p. 3). Like Zhang, the model of SMAs links up with the basic psychological needs as outlined by SDT, namely autonomy, competence and relatedness. SDT has found increasing acceptance as an explanatory model for gaming enjoyment and motivation. Need satisfaction explains why people seek out and continue to engage in gaming (Deterding, 2011).

Hamari, Koivisto and Sarsa (2014) utilise the term *motivational affordances* to refer technically to commonly used game elements, which differs somewhat from the conceptual model introduced by Deterding (2011). Deterding (2011) asserts that it is the user's relation to game elements in a given state and surrounding situation that supports need satisfaction of autonomy, competence and relatedness. Chapter 2 introduced a *Taxonomy of Game Design Elements* (Deterding et al., 2011), explaining the different aspects of identified and frequently used game elements (see Table 2.2). Simply substituting the term "game element", however, with "motivational affordances", and assuming that game elements alone, regardless of context and situation, are equivalent to SMAs as defined by Deterding (2011) diminishes the possibility of exploring the deeper granular layers of the motivational pull of gameful design.

Despite their somewhat differing definition, Hamari, Koivisto and Sarsa (2014) outline a conceptualisation model (Figure 3.2) that depicts the process flow of motivational affordances, psychological outcomes and behavioural outcomes in gamefully designed contexts.

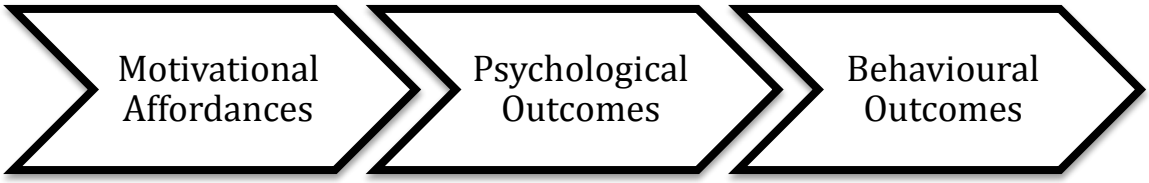


Figure 3.2: Conceptualisation of Gamification (Hamari, Koivisto & Sarsa, 2014)

This model was created in an effort to strategically evaluate existing research on gameful design and make a connection of the conceptualisation of gameful design to frequently utilised practices (Hamari, Koivisto & Sarsa 2014). Although Hamari, Koivisto and Sarsa (2014) provide an essential review of existing literature within gameful design using said process flow model to conceptualise gameful design, there is a lack of depth related to the concept of situated motivational affordances as introduced by Deterding (2011). That depth could provide the sought-after linkage between the concepts at hand. The opportunity to evaluate the more granular levels of gameful design in order to gain a deeper understanding of connections to SDT and behavioural outcomes is not realised in Hamari, Koivisto and Sarsa's (2014) approach. However, utilising the conceptual process flow model introduced by Hamari, Koivisto and Sarsa (2014) and adapting it to include Deterding's (2011) definition, as well as a deeper conceptualisation of SMAs, can provide a strong, newly formulated foundation of flow for the creation of a novel theoretical framework within gameful design studies (Figure 3.3).

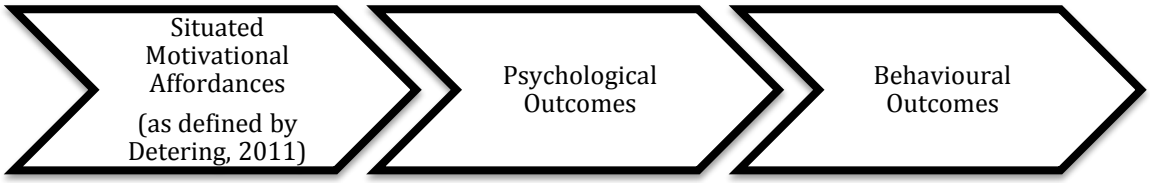


Figure 3.3: Modified Conceptualisation of Gameful Design

Every person will have a different experience during the engagement with gamefully designed applications, whether it is a whole game or not. To provide an experience of enjoyment and engagement eliciting psychological outcomes like motivation, it is vital to find multiple pathways to satisfy the three basic psychological needs of autonomy, competence and relatedness. Thus, it is essential to provide a vast array of SMAs to involve people in different situations and contexts in order to enhance the likelihood of satisfying the three basic psychological needs. Need satisfaction produces and explains enjoyment and engagement in a game or gamefully designed application. Therefore, a wide variety of SMAs expressed through various options of game elements supported by game features should be employed in intervention designs with the particular aim of psychological and behavioural outcomes impacting a larger number of people. Thus far, however, no known concrete list of SMAs within gameful design for any particular context exists; thus, it is essential to establish a baseline of such to be able to connect the psychological and behavioural outcomes as shown in Figure 3.3 for a theoretical framework.

The establishment of a novel theoretical framework presenting a baseline example of a comprehensive set of SMAs for the application in gameful design contexts requires the detailed analysis of existing practices and applications to inform the selection and articulation of specific SMAs. Hamari, Koivisto & Sarsa (2014), examined 24 empirical studies employing gameful design strategies and specifically reviewed the usage of motivational affordances (expressed in simplified game elements) and their impact on psychological and behavioural outcomes. The findings of this review prompted a design of 10 motivational affordances (expressed in simplified game elements) categories reoccurring throughout the sampled studies. The most frequently tested elements were points, leader boards and badges (Anderson et al., 2013; Cheong, Cheong & Filippou, 2013; Dominguez et al., 2013; Farzan et al., 2008; Grant & Betts, 2013; Halan et al., 2010; Hamari & Koivisto, 2013; Montola et al., 2009; Thom, Millen & DiMicco, 2012). In another study, Li, Grossman and Fitzmaurice (2012) showed that points were amongst the game elements that produced positive results by increasing enjoyment, enhancing learning and improving engagement in a study to improve existing tutorial systems. Further, Cafazzo et al. (2012) showcased a 50% increase in daily blood glucose measurements through the use of points and rewards. In yet another study on crowdsourcing, Liu, Alexandrova and Nakajima (2011) positively encouraged participation by improved response quality and speed utilising points, badges, status and leader boards. To support the onboarding during orientation processes, Depura and Garg (2012) employed leader boards, badges, mini-games and rewards, leading to positive behavioural changes in social bonding, increased productivity and knowledge acquisition.

In their extensive work, grounded in SDT, Rigby and Ryan (2011) unfold the concept of SMAs in great depth without actually utilising this terminology, precisely matching the modified conceptualisation of gameful design as presented in Figure 3.3 above. Rather than focusing on describing specific applications of

simplistic game elements like points, badges or leader boards, they showcase the more objective conceptualisation of them. In relation to the above-mentioned game elements of points, badges and leader boards, the concepts of cumulative, granular and sustained competence feedback and competitive play give room for the consideration of context and situation.

Cumulative competence feedback in this category takes on the form of the total score or progression in a game, which provides a greater sense of mastery and skill (Rigby & Ryan, 2011). Furthermore, it aids in the lasting player experience. Specific examples of game element expressions may include game collectibles, such as points. Further, the player may receive greater strength, or more advanced weapons, better equipment or increased abilities as part of the game. This type of situation affords the perceived psychological need of competence (Rigby & Ryan, 2011).

Granular competence feedback refers to the immediate feedback a player receives for each performed action within the game or gamefully designed application (Rigby & Ryan, 2011). Common game features utilised to express granular competence feedback include: rewards (e.g. points or badges), progress bars, various noises, pop-up messages and continuous play. Players immediately feel more competent playing the game when receiving granular competence feedback (Rigby & Ryan, 2011).

Slightly different from the aforementioned cumulative competence feedback is **sustained competence feedback**, which includes mechanisms that communicate to the player that they are experiencing an unbroken streak of achievement and mastery. In other words, players are “on a roll” (Rigby & Ryan, 2011). This type of feedback can be expressed through sound (such as roars from the crowd) or through visual meters and multipliers. Again, receiving such feedback provides a feeling of competence and mastery for the player (Rigby & Ryan, 2011).

Competitive play within game contexts can act as a sharpening tool to empower others to improve (Rigby & Ryan, 2011). Competitive play can also establish meaningful and supportive connections, particularly through relatedness within a team context. Examples of game elements employed to create such contexts include: leader boards, comparative progress boards and real-time competition. Competitive play may also tie into the SMA of cooperation (discussed later): learning how to work together, having specific responsibilities and roles and providing feedback to each other in order to work towards a common goal. However, it is essential to realise the potential negative associations competition can create for particular activities. Due to the fact that each player will respond differently to specific SMAs, it is essential to provide a variety, so players have the choice to either participate in competitive play or not. For some, this can elicit a feeling of relatedness and also of competence. Others may feel pressure to perform, which can result in positive or negative behavioural outcomes. For some players, this SMA may be the only game feature that keeps them engaged and involved, leading to desired psychological outcomes and therefore desired behavioural outcomes. Within the technological game context, competition usually manifests itself differently than in physical game contexts and the responses may vary accordingly.

Based on their review of existing empirical studies within gameful design, Hamari, Koivisto & Sarsa (2014) determined seven further categories of motivational affordances, also frequently utilised: levels, story/theme, clear goals, feedback,

rewards, progress and challenge (Anderson et al. 2013; Dong et al., 2012; Gustafsson & Bang, 2008; Hamari & Koivisto, 2013; Li, Grossman & Fitzmaurice, 2012). Within a study by Dominguez et al. (2013), levels, challenges, badges and leader boards increased initial motivation and a better practical score within the context of education. A health and wellness study focused on encouraging smiling utilised the game element of levels to increase the amount of smiles, which led to greater positive social outcomes (Hori et al., 2013). Downes-Le Guin et al. (2012) employed levels, avatars, rewards and narrative to improve the experience and the data quality within marketing, which led to higher rates of satisfaction; however, engagement seemed to remain unaffected. Through the use of immediate and affective avatar-based feedback, Berengueres et al. (2013) positively encouraged the use of recycling bins at rates three times increased. Rose, Koenig and Wiesbauer (2013) improved health and wellness behaviour compliance, resulting, for example, in reduced blood sugar and improved quality of life, by way of points, challenges, avatars and progression.

Rigby and Ryan (2011) conceptualise the above-mentioned frequently utilised motivational affordances in a grander, more multifaceted fashion. In reference to **goal-setting**, they indicated that this is a key component in gameful design and provides direction for the player, allowing him or her to regulate a personal journey and set expected outcomes. Goal setting within a game can be expressed through a variety of different game features, including, for example, direct goal setting as it pertains to certain activities, missions, quests and achievements and can be effective as illustrated in previous research (Anderson et al., 2013; Denny, 2013; Dominguez et al., 2013; Grant & Betts, 2013; Hamari & Koivisto, 2013; Montola et al. 2009). When missions and quests are completed successfully, players usually receive rewards for completing their goals and are provided with opportunities to focus on new goals. Having an opportunity to achieve goals satisfies the basic psychological need of competence, which provides feelings of efficacy and challenge (White, 1959; Deci, 1975). Further, goal setting has known motivational effects beyond competence in different contexts (Ryan, 2012).

Creating **opportunities for goal choice** within gameful design allows users to have a choice in selecting from a set of goals or even articulating their own goals (Rigby & Ryan, 2011). An example here would be a quest system in online role-playing games, where multiple quests exist at once and the player can choose which quest to pursue. This SMA allows users to experience feelings of autonomy (Rigby & Ryan, 2011).

Challenges are built into the game and can be expressed in many different ways, depending on the game genre. For example, within a music game, the difficulty of songs could present an optimal challenge. In a strategic game, the difficulty of puzzles or maps could form a challenge for the player. Rigby and Ryan (2011) explain that optimal challenges satisfy the need for competence by providing a feeling of mastery through perceived skills. Challenges too high can cause frustration and challenges too low can lead to boredom. Optimising challenges for the player ensures that neither occurs. Fitz-Walter, Tjondronegoro and Wyeth (2012) incorporated challenges into their study and reported positive outcomes in relation to engagement during orientation processes; thus, the target group received these challenges as optimal within the given context.

Games and gamefully designed applications provide the neat possibility to take on “characters” or “avatars”, allowing the player to create a new personality different from their real self. Usually, this type of character is referred to as an avatar within gameful design (Rose, Koenig and Wiesbauer, 2013; Liu,

Alexandrova and Nakajima, 2011; Downes-Le Guin et al., 2012). Following Rigby and Ryan (2011), it is not so much the presence of an avatar per se that motivates; avatars motivate to the extent that they provide meaningful **opportunities for identity choice**, giving the player a feeling of autonomy in choosing to take on a different gender, race or physical appearance, or ability (Rigby & Ryan, 2011).

Another related SMA is providing players **opportunities to choose how to act in a game,** including strategies, solutions and tactics to solve challenges, prompting action to take place (Rigby & Ryan, 2011). An example of this is finding oneself behind a locked door and figuring out a way to get through or past it by exploring different options. This SMA allows the player to feel more autonomous within the game context. Li, Grossman and Fitzmaurice (2012) implemented challenges, levels, rewards and time pressure within the context of education and showcased evidence of improved enjoyment and engagement.

Relatedly, **open-world designs** within gamefully designed contexts on the one hand are an umbrella for the previous opportunities for goal and action choice. On the other hand, being in a wide-open space, even a virtual one, allows players to proceed the way they choose to. This unique SMA, more frequently employed in serious games, fosters a feeling of autonomy for the player, as he/she experiences a literal physical opportunity space (Rigby & Ryan, 2011).

Opportunities for receiving or giving acknowledgement, either through body language or words, can elicit a feeling of relatedness and could be categorized as a type of feedback. A social connection is established and within a game context this can occur via actual game players or even between fictional characters and the player (Rigby & Ryan, 2011). Acknowledgement may also be perceived as receiving social support in some instances or even foster a type of companionship contributing to perceived relatedness (Sarason, Sarason and Gurung, 2001).

Opportunities for receiving support can be a very important SMA within a game context, as it allows players to connect with other players or with designed characters (Rigby & Ryan, 2011). We want others to know what we are feeling and we want to be understood and supported in the actions we take. Opportunities for support within games can enhance the feeling of relatedness and go beyond opportunities for acknowledgement (Rigby & Ryan, 2011). Interpersonal relatedness is extremely vital for happiness and wellbeing (Baumeister & Leary, 1995), and humans have a deep innate desire to be connected, which satisfies this basic psychological need, leading to increased motivation (Rigby & Ryan, 2011).

Humans want to see how they can impact others positively. We want to have **opportunities to positively support others**. This might be expressed via sharing laughter during a joke or through emotional connections that potentially arise from shared experiences: a dependence between two people or in the game context perhaps between the player and a character. Again, opportunities for impact can satisfy the need for relatedness (Rigby & Ryan, 2011).

Cooperation within gameful design refers to the situation in which two or more players team up and work together. Cooperation requires teamwork and reliance on one another to protect each other and move forward together in the game or gamefully designed context. With advanced technology, this type of SMA can be achieved either with two people physically in the same location or with two or more people playing cooperatively from different places throughout the world. The

basic psychological need of relatedness is satisfied through cooperation, but interestingly, as Rigby and Ryan (2011) assert, feelings of autonomy and competence are also elicited. Furthermore, a strong sense of social support is derived from cooperation, which often leads players to play for hours with one another.

To conceptualise a strategic approach to identifying and selecting SMAs for inclusion in a baseline framework development, the three basic psychological needs (competence, autonomy and relatedness), form the structure for organised categorisation (Table 3.1). Only the items discussed within existing research that could be identified as an SMA concept, satisfying at least one of the basic psychological needs (competence, autonomy or relatedness), were included in the newly created list of SMAs (Table 3.1). Although not equivalent to a complete validation, which is outside the scope of this thesis, the finalised, first of its kind list of SMAs, as presented in Table 3.1. was reviewed directly by Deterding, who is among the leading researchers within the field of gameful design worldwide. Based on the fact that the creation of this theoretical framework of SMAs is a novel contribution to the current body of research, it is highly likely that new SMAs will be discovered. The list of SMAs as presented here does not claim comprehensiveness, but is rather a foundational baseline to build on for future research and exploration. Each selected SMA showcased in the newly established list presents a separate and effective route to targeted psychological effects (Rigby & Ryan, 2011). To formalise validation through future work, experiments and Factor Analyses could be conducted. Table 3.1 provides a novel creation of SMAs linked to SDT constructs within the context of gameful design, constructs based on the existing research presented in this section.

Table 3.1: List of 14 SMAs

	SMA	**SDT Construct Linkage (Theoretical Mediator)**
1	Opportunities for Goal Setting	Competence
2	Optimal Challenges	Competence
3	Cumulative Competence Feedback	Competence
4	Sustained Competence Feedback	Competence
5	Granular Competence Feedback	Competence
6	Opportunities for Identity Choice	Autonomy
7	Opportunities for Goal Choice	Autonomy
8	Opportunities for Action Choice	Autonomy
9	Open-World Designs	Autonomy
10	Opportunities for Acknowledgement	Relatedness
11	Opportunities for Support	Relatedness
12	Opportunities for Impact	Relatedness
13	Cooperation	Relatedness, Competence & Autonomy
14	Competitive Play	Relatedness & Competence

This section provided a deeper exploration of concepts of motivation via gameful design to determine further potential for framework development. Based on the evaluation of current understanding within the field, SDT provides a promising theoretical base, which has been successfully linked to gamification principles (Aparicio et al., 2012; Sailer et al., 2013; Seaborn & Fels, 2015). SMAs embody a

deeper, more granular conceptualisation within gameful design (Deterding, 2011), having evidenced the ability to trigger psychological outcomes such as motivation, further leading to behavioural outcomes in a variety of contexts (Hamari, Koivisto & Sarsa, 2014). The work of this section has resulted in the adaptation of a newly modified conceptualisation of gameful design (see Figure 3.3) providing a foundation for the development of a comprehensive theoretical framework. In addition, the articulation of 14 SMAs, primarily based on the most thorough evidence-based work on this subject of Rigby and Ryan (2011), linked to SDT constructs (see Table 3.1), showcased the inception of a new taxonomy, which will be further developed in the second stage of *Study 1*. The next section will explore important theoretical concepts of behaviour change techniques, which presently are not connected to motivation and gameful design principles within available research.

3.2.2 Theoretical Concepts of Behaviour Change Techniques

Behaviour change concepts, theories and models are critical for comprehending the connections between a person's psychological and behavioural outcomes. Behaviour change theories and models assist in the explanation of behavioural phenomena, prediction regarding behaviour in the future, understanding of behavioural processes and the provision of frameworks to be applied to research in order to evaluate the effectiveness of behaviour change interventions. Well-studied behaviour change models and theories that can be applied to a variety of behaviours include, but are not limited to: Health Belief Model; Theory of Planned Behavior; Theory of Reasoned Action; Self-Efficacy Theory; Transtheoretical Model; Relapse Prevention Model (McKenzie, Neiger & Thackeray, 2012).

Designing behaviour change interventions grounded in theoretical frameworks is a complex and challenging task. The key element, however, of any behaviour change intervention is the content of an intervention. This is referred to as the "active ingredient" (Michie et al., 2013) leading to changes in the desired behaviours. Due to the previous absence of clear definitions of content in health behaviour change research, despite the varied availability of broad theories and models, Michie et al. (2013) perceived standard descriptions as necessary and thus created a classification of behaviour change techniques (BCTs).

BCTs are methods utilised in behaviour change interventions to alter behaviour and they can be used individually or in combination, including varying formats (Michie et al., 2013). Well-established and defined BCTs have the potential to cause the intervention to have a greater effect and have been successfully linked with self-regulatory techniques (Greaves et al., 2011).

In 2008, Abraham and Michie defined 26 theory-linked BCTs as a result of three systematic reviews of behaviour change interventions evaluating a variety of different behaviours. Developing clear definitions and detailed characterisations would potentially provide a better insight into the impact of BCTs on differences and effectiveness (Abraham & Michie, 2008). Furthermore, standardised descriptions of specific BCTs would allow research studies to replicate applications.

Based on the perceived need to further precisely illustrate the content of interventions for greater specificity, Michie, van Stralen and West (2011) developed a refined taxonomy of behaviour change techniques specifically focused on physical activity and healthy eating behaviours: The CALO-RE taxonomy (see Appendix 3.1). This was done with the aim to expand the scope of the 26-item behaviour change taxonomy (Abraham & Michie, 2008), to improve

the reliability and to optimise scientific reporting of studies (Michie, van Stralen and West, 2011). The CALO-RE taxonomy evidenced positive revisions and additions, resulting in a 40-item taxonomy (see Appendix 3.1).

In 2013, Michie et al. revised the original 26 theory-linked BCTs and established the Behaviour Change Technique Taxonomy of 93 techniques. These 93 BCTs are identified within 16 different clusters (Appendix 3.2) and build the foundation for behaviour change interventions in a systematic and reliable fashion (Michie et al., 2013). Despite the development of varying taxonomies of BCTs, these frameworks are only now being tested and applied, and thus it is possible that further evolution of these concepts will be necessary as research produces relevant findings. However, previous research employing behaviour change techniques grounded in behaviour change theory has been linked to effectiveness (Abraham & Michie, 2008).

The delivery mode of computing technology has brought about many new pathways for reaching larger numbers of people through technological health behaviour interventions than before. Interestingly, however, it appears that there is a serious discrepancy between the explosion of web- and mobile-based commercial health and fitness applications and the employment of evidence-based behaviour change theories and techniques (Cowan et al., 2013).

In a recent review and content analysis of current available mobile-based physical activity applications (Middelweerd et al., 2014), 64 were reviewed based on the original BCT taxonomy designed by Abraham and Michie (2008) to determine the implementation of various BCTs. Results showed that on average only five BCTs were employed, with the most common techniques being: (1) self-monitoring; (2) feedback and (3) goal-setting (Middelweerd et al., 2014). There seemed to be no differences between free and paid applications in terms of BCTs utilised and interestingly the most frequently used BCTs in this review were similar to those utilised most frequently in other types of interventions (non-technologically based) to promote physical activity behaviour (Middelweerd et al., 2014). It is very important to note that the researchers in this study had to translate Abraham and Michie's (2008) taxonomy to mobile-based application functionalities, which did not exactly resemble the original terminology of BCTs (Middelweerd et al., 2014).

Conroy, Yang and Maher (2014) reviewed and ranked top mobile-based applications aimed to impact physical activity behaviour and coded them according to the CALO-RE taxonomy (Appendix 3.1). Findings in this study determined two categories of applications, with one having a focus on educational features and another centralising on motivation for physical activity (Conroy, Yang & Maher, 2014). Further, this review revealed that BCTs were employed sparingly and that the most frequently utilised techniques were: (1) instruction for behaviour performance; (2) modelling of behaviour; (3) feedback; (4) goal-setting and (5) social support (Conroy, Yang & Maher, 2014).

Yang, Maher and Conroy (2015) embarked on a study to evaluate mobile-based physical activity applications in relation to the most recent BCT taxonomy employing 93 items (Appendix 3.2). This study observed the usage of 39 BCTs overall in all the coded applications, with an average usage of 6.6 BCTs in each. The most frequently used BCTs identified in this study were: (1) social support; (2) approval of others; (3) instruction for behaviour performance; (4) modelling of behaviour; and (5) feedback (Yang, Maher & Conroy, 2015).

All three recent studies (Middelweerd et al., 2014; Conroy, Yang & Maher, 2014; Yang, Maher & Conroy, 2015) evaluating the usage of BCTs in mobile-based physical activity applications underlined two key points. First, although BCTs were utilised, there is potential for greater usage of BCTs within the emerging field of technological applications aimed at health behaviour change. Second, there is a need to evaluate mobile-based physical activity applications for effectiveness in relation to actual behaviour change. Further recommendations included the future partnerships of application developers and behaviour change specialists for greater impact.

Interestingly, none of the available research studies focused on mobile-based physical activity applications made obvious connections between concepts of gamification, motivational theory and behaviour change theories. The only potential linkage articulated in Middelweerd et al.'s (2014) research related to the translation of BCTs to application functionalities, which very well could also be identified as gamification features. Only in a very recent critical review was a clear conceptual connection alluded to (Helf & Hlavacs, 2016), with the point that the emergence of a plethora of mobile-based physical activity applications lends itself to the possibility of connecting to motivational theory, gamification principles and health behaviour change techniques. Helf and Hlavacs (2016) conclude that this connection of disciplines presents a promising gap to fill within current research and practice indicating that an interdisciplinary approach may promise the greatest chance for success in the future development of mobile-based physical activity applications (Helf & Hlavacs, 2016).

The taxonomies of BCTs are methodological tools to assist with the specification of intervention content. Michie et al. (2013) comment that the mode and context of BCT delivery can have an even greater impact on the outcome than the techniques themselves and that the development of additional specified contextualised taxonomies would be beneficial and form a key research goal within the field of behaviour change. This conclusion closely resembles that of Deterding (2011) in relation to gamification, namely that situation and context can greatly impact motivational levels, which in turn impacts engagement levels and thus behavioural outcomes.

The next section presents the development of the theoretical framework linking existing theories of motivation, gamification and BCTs specifically relevant for physical activity behaviour. This newly integrated and interdisciplinary approach responds to the identified gaps in present literature, research results and understanding, building a further layer of the foundational framework for this study.

3.3 Research Process Model – Stage 2

Gamification presents a unique opportunity to potentially contribute to behavioural changes as a result of meeting basic psychological needs as outlined in SDT. SMAs provide a pathway to tease out how game design supports psychological outcomes (motivation) and in turn behavioural outcomes. To date, no methodological frameworks or tools have been developed to address these needs. As outlined in the previous section, BCTs are regularly utilised in health behaviour change interventions, such as those focused on physical activity behaviour. BCTs have proven effective; however, often they have not been matched to theoretical mediators (Michie et al., 2013).

This section presents a new taxonomy of SMAs in gamification linked with SDT constructs and a clear mapping of possible matching BCTs based on the CALO-RE taxonomy. Based on the context of this study, the CALO-RE taxonomy was chosen for the purposes of mapping BCTs, as it was designed with a particular focus on physical activity. This interdisciplinary approach provides a new framework to support the modified conceptual model of gamification (see Figure 3.3), which outlines the flow of SMAs, psychological outcomes and behavioural outcomes.

Table 3.2 presents this new *Taxonomy of Situated Motivational Affordances in Gamification* based on the in-depth evaluation of current theoretical bases and evidence-based research as presented in this and in the previous chapter. Further, this taxonomy (Table 3.2) provides examples of related game features as they might appear in computing technological applications. These examples of game features were also extracted from the work of Rigby and Ryan (2011). The intention of mapping BCTs as part of this new taxonomy was to demonstrate possible parallels to SMAs within gamification. Indeed, there are several identified parallels between SMAs and BCTs; however, there are also a number of unique opportunities SMAs present within gamification. These may provide additional pathways to prompt certain psychological outcomes and lead to desired behavioural outcomes when gamification is utilised for behaviour change.

Based on the development of this new taxonomy, it would be ideal to create a unique technological intervention application. This approach was explored at length; however, for the purpose of this PhD thesis it was not feasible to embark on this endeavour due to lack of finances, legal restrictions and practical logistics. Thus, it was necessary to choose an existing application for the selection of the intervention for the *Intervention Implementation Study* to be conducted (see Chapter 4). The detailed selection criteria for an appropriate intervention application based on the development of the new theoretical framework are presented in the next section.

3.4 Research Process Model – Stage 3

3.4.1 Development of Criteria for Intervention Selection

The establishment of specific criteria for the selection of an intervention application for the *Intervention Implementation Study* (*Study 2*) resulted in the creation of an inclusion criteria checklist (see Table 3.3). This checklist includes eleven inclusion criteria, which are based on evidence-based principles within gamification, motivational theory and behaviour change theory research; it yields issues related to specificity and feasibility for this PhD research thesis. The checklist (Table 3.3) includes the following: (1) the inclusion criteria; (2) the selection rationale; and (3) the source for evidence-based research.

Inclusion criteria *one*, *two* and *three* relate to the greater accessibility of the application for a wider population, which will particularly allow researchers in an intervention setting to collect data on a larger community of people. Inclusion criterion one asserts that the application must be accessible via both main operating systems available: Apple iTunes and Google Play. Inclusion criterion two points to the essential issue of affordability (i.e., no charge). Many commercial gamified applications for health-related settings require a fee from the user, but there are also many available that are free of charge. For the purpose of conducting research via an intervention as part of a PhD research thesis, it is

desirable to utilise applications that are affordable, thus free of charge, which again means increased accessibility for a wider range of participants.

Criterion three states that no additional tracking devices must be required to use a particular application, as some do. This would incur additional, sometimes substantial, charges, which would limit the recruitment population to those that have access to finances and resources to purchase these devices. An example of such an application is the FitBit Activity Tracker system.

The main focus and target health behaviour of this thesis is physical activity, thus, inclusion criterion four states that the chosen application must have a particular focus on physical activity. Further, criterion five denotes the importance of context-fitting technology as evidenced in research limitations highlighted by Gotsis et al. (2013) and Hurling et al. (2007). Both studies point out the importance of utilising appropriate technology (e.g. web- and mobile-based computing technology). To increase accessibility for a research intervention, it is therefore desirable to choose an application that can be accessed and used through both mediums: web- and mobile-based.

Inclusion criterion six was chosen to appeal to, again, a wider range of people and not restrict the activities to specific types of physical activities only, which many commercial applications have done (i.e. running or biking only, etc.). Furthermore, the ability to choose activities within a gamified application responds to the basic psychological need of autonomy, and the opportunity of choice, leading to greater levels of internalised motivation (Rigby & Ryan, 2011).

Modern-day technology presents a challenge in that different generations interact variably with it. It is important that the design of the content and aesthetics of health-related applications correspond with the target population (i.e., adults in this study) to foster participation. It is possible, however, that particular applications are designed to appeal to a wide range of age groups and do not have the above-mentioned limitation. Inclusion criterion seven corresponds to the need to select an application corresponding with the target audience of the intervention (Rigby & Ryan, 2011).

Inclusion criterion eight was developed based on the establishment of the new taxonomy of SMAs in gamification in the previous section. This taxonomy provides a deeper insight into the design of specific game features with explicit purposes and understanding of theoretical mediators to elicit precise psychological and behavioural outcomes. The detailed list of references supporting the selection of this criterion can be found in Table 3.3. The criterion clearly asserts that the selected application must correspond to all three basic psychological needs: autonomy, competence and relatedness (SDT) as designed through the SMAs employed.

The provision of foundational education and information about the target activity for safety purposes and better decision-making capabilities is an important element of an application commercially, but particularly for the purposes of a research intervention. Thus inclusion criterion nine asserts that educational information about physical activity for this particular intervention selection process be integrated into the application in some way to ensure safe participation.

Inclusion criterion ten asserts that users must have the ability to record or track their physical activity data in some way within the gamified application to be able

to receive a variety of feedback built into the game context and for researchers to be able to track engagement with the gamified application.

In order for researchers to obtain valuable data for evaluation, it is key that the chosen application has the capability to store users' data. The access to this data should be available to the participant and the researcher, thus serving multiple purposes. Therefore, inclusion criterion eleven specifies that the application provide the possibility to store users' data.

The inclusion criteria checklist (Table 3.3) is specifically designed for the purpose of this study to select an appropriate and feasible intervention for the *Intervention Implementation Study (Study 2).* The rationale for each articulated criterion relates either to current research conclusions or to the specific needs of this particular PhD research thesis in relation to feasibility and specificity.

In response to the completion of an inclusion criteria checklist, an exclusion criteria checklist was created to assist with the narrowing of choices of commercial applications, as there is such a multitude of choices available via the different application store platforms. The following exclusion criteria were determined, corresponding specifically to the different inclusion criteria categories: (1) available via only one operating system; (2) incurring costs; (3) requiring additional equipment/tracking device; (4) focusing on health behaviour other than physical activity; (5) web- or app-based only; (6) limited to specific physical activities (e.g. running); (7) designed specifically for children or for a limited population (e.g., those suffering a particular medical condition); (8) having a limited inclusion of SMAs expressed via game features corresponding to only one theoretical mediator or SDT; (9) containing little or no educational information about physical activity embedded in the application; (10) offering no option for users to log any personal physical activity data and (11) offering no option for storing physical activity data.

The establishment of detailed criteria for the selection of an appropriate intervention application for the purpose of *Study 2* was a necessary step in the process leading to the next, which entails the review of available gamefully designed physical activity applications delivered via computing technology. Although the inclusion criteria checklist (Table 3.3) was specifically developed for the selection of an intervention application in this study, it may be applicable to future research studies aiming to conduct an intervention using a gamefully designed application, even in different contexts. For such, this checklist could be adapted and modified to be applicable.

Table 3.2: Taxonomy of Situated Motivational Affordances for Gameful Design

	SMAs	SDT Linkage (Theoretical Mediator)	Examples of Supporting Game Features	Possible BCT parallel to SMA (Appendix 3.1)
1	**Opportunities for Goal Setting**	-Perceptions of competence	-Specific, measurable, attainable goals -Timed quests/missions	-Goal setting (behaviour) (BCT #5) -Goal setting (outcome) (BCT #6)
2	**Optimal Challenges**	-Perceptions of competence	-Balanced difficulty -Balanced complexity	-Barrier identification/ Problem solving (BCT #8) -Prompt self-monitoring of behaviour (BCT #16) -Prompt self-monitoring of behavioural outcome (BCT #17)
3	**Cumulative Competence Feedback**	-Perceptions of competence	-Levels -Increase in strength -Reputation -Receipt of new items that unlock new abilities -Skills as player advances -Increase in abilities -Advancing in tournaments -Improving win-loss records -Game “collectibles”, score/points	-Provide rewards contingent on successful behaviour (BCT #13) -Provide feedback on performance (BCT #19)
4	**Sustained Competence Feedback**	-Perceptions of competence	-Score multipliers -Positive sound and visual feedback -Power-ups -Chaining actions successfully to overcome obstacles and reach new goals	-Prompt rewards contingent on effort or progress towards behaviour (BCT #13) -Provide feedback on performance (BCT #19)

Table 3.2 continued: Taxonomy of Situated Motivational Affordances for Gameful Design

	Situated Motivational Affordances	**Theoretical Mediator(s) (SDT-related)**	**Examples of Supporting Game Features**	**Possible BCT parallel to SMA** (Appendix 3.1)
5	**Granular Competence Feedback**	-Perceptions of competence	-Progress bar -Visual/auditory cues for each note -Blood and enemy reaction when hit -Smoke -Sound -Rumbles -Representational feedback from on-screen meters -Rewards (points, badges)	-Prompt review of behavioural goals (BCT #10) -Prompt review of outcome goals (BCT #11) -Provide feedback on performance (BCT #19)
6	**Opportunities for Identity Choice**	-Perceptions of autonomy	-Creation of individually customised avatars -Freedom to take on roles different from real life	**N/A**
7	**Opportunities for Goal Choice**	-Perceptions of autonomy	-Choice and agency in selecting from set of goals or articulating own goals [Examples: quests & missions]	-Goal setting (behaviour) (BCT #5) -Goal setting (outcome) (BCT #6)
8	**Opportunities for Action Choice**	-Perceptions of autonomy	-Multiple hierarchical levels of human action available -Opportunities for strategic action -Multiple routes to the same goal (sneaking by, shooting, negotiating with non-player character) -More granular opportunities for action (usage of different weapons in a given situation)	-Action planning (BCT #7)

Table 3.2 continued: Taxonomy of Situated Motivational Affordances for Gameful Design

	Situated Motivational Affordances	**Theoretical Mediator(s) (SDT-related)**	**Examples of Supporting Game Features**	**Possible BCT parallel to SMA** (Appendix 3.1)
9	**Open-World Designs**	-Perceptions of autonomy	-Vast levels -Choices to explore different environments [Example: *Fallout 3:* After an hour-long introduction of being constrained in an underground vault, the player is released into a vast open landscape filled with cities, people, missions and dangers, and is free to go anywhere and do anything they wish.]	
10	**Opportunities for Acknowledgement**	-Perceptions of relatedness	-Leader boards -Message boards -Character's words and actions -Gifting mechanisms -Real-time chat	- Provide information about others' approval (BCT #3) -Provide feedback on performance (BCT #19)
11	**Opportunities for Support**	-Perceptions of relatedness	-Organisation of players into teams -Joint goals -Friend bar -Starter friend -Pictures of friends greeting you at start of game -Message boards/feedback -Real-time chat	- Provide information about others' approval (BCT #2) -Plan social support/ social change (BCT #29)
12	**Opportunities for Impact**	-Perceptions of relatedness	-Gifting mechanisms -Message boards/feedback -One player's goals dependent on other players' actions	-Prompt identification as role model/position advocate (BCT #30)

Table 3.2 continued: Taxonomy of Situated Motivational Affordances for Gameful Design

	Situated Motivational Affordances	**Theoretical Mediator(s) (SDT-related)**	**Examples of Supporting Game Features**	**Possible BCT parallel to SMA** (Appendix 3.1)
13	**Cooperation**	-Perceptions of relatedness -Perceptions of autonomy -Perceptions of competence	-Joint team goals -Gathering friends into teams/groups/gangs -Team play	-Provide normative information about others' behaviour (BCT #4) -Facilitate social comparison (BCT #28) -Plan social support/social change (BCT #29)
14	**Competitive Play**	-Perceptions of relatedness -Perception of competence	-Leader boards -Comparative progress boards -Real-time competition -Tournaments & matches -Receiving glory/fame without advancements	-Provide normative information about others' behaviour (BCT #4) -Facilitate social comparison (BCT #28)

3.4.2 Selection of Intervention Application

Mobile computing technology is increasingly becoming the delivery tool of many different applications, particularly within health and fitness. Due to its recent emergence, very little research is currently available regarding physical activity mobile applications for the purpose of a strategic selection of an appropriate application for this study. The first part of this section will entail a detailed review of the current limited available research leading to the selection process of a physical activity application. The following part will outline the actual selection process.

West et al. (2012) conducted a content analysis of paid health and fitness apps; however, it was not specifically focused on physical activity. The Health Education Curriculum Analysis Tool (HECAT) and the Precede-Proceed Model (PPM) were used in this particular study to code 3336 paid health and fitness apps. Findings showed that only 62 of the paid apps included all three factors: predisposing, enabling and reinforcing. This study does not provide helpful information regarding the screening and selection of available applications for this study, as the focus was not narrowed on physical activity applications and West et al.'s study utilised different theoretical frameworks for evaluation and measuring.

Pagoto et al. (2013) conducted an investigation to identify weight-loss applications available on iPhone and Android platforms, which included any behavioural strategies for weight loss. Based on their research, iTunes listed a total of 400 health and fitness applications and Android Market listed 480 health and fitness applications in January 2012. This list included paid and free applications and did not specifically identify applications focused on physical activity. Based on the objectives of this study, Pagoto et al.'s (2013) search criteria and results do not match the purpose of this study, and thus is not a good choice for the selection process.

Cowan et al. (2013) completed a content analysis of health behaviour theories represented in physical activity applications available for iPhone. The theories employed in this study included the: (1) health belief model; (2) theory of reasoned action/planned behaviour; (3) transtheoretical model; and (4) social cognitive theory/social learning theory. 127 physical activity applications were selected for coding, without restrictions regarding type of exercise or population (e.g. children, adults, etc.). The results of this study indicate that most of the selected and coded applications did not include theoretical health behaviour constructs (10.1 out of 100 on average). Based on the objectives, methodology and approach for inclusion criteria, which all differ quite significantly from this study, Cowen et al. (2013) does not represent the best option for a selection strategy.

Table 3.3: Inclusion Criteria Checklist

	Criteria	Rationale	Source
1	Must be **available via Apple iTunes and Google Play**	-Increased accessibility for a wider range of people, especially for the purpose of a research intervention	[Research team consultation: Stathi, A., Deterding, S. & Medina, E., 2014]
2	Affordable (no charge): **free to all users**	-Increased accessibility for a wider range of people, especially for the purpose of a research intervention	[Research team consultation: Stathi, A., Deterding, S. & Medina, E., 2014]
3	**Does not require additional equipment or tracking devices**	-Increased accessibility for a wider range of people, especially for the purpose of a research intervention	[Research team consultation: Stathi, A., Deterding, S. & Medina, E., 2014]
4	**Focus on physical activity**	-Outcome specificity -Population specificity -Context of this PhD research study	[Research team consultation: Stathi, A., Deterding, S. & Medina, E., 2014]
5	Context-fitting technology platform: **web- & mobile-based**	-Increased accessibility for a wider range of people -Appropriate and functioning technology/software	-Gotsis et al. (2013) -Hurling et al. (2007)
6	Capability to allow users to engage in **physical activity of their choice**	-Theoretical framework: PENS, Taxonomy of SMAs in gamification -Greater application to a larger variety of people	- Rigby & Ryan (2011)
7	Relevant population: **adults**	-Appropriate applications/game features (content and design) for target population	- Rigby & Ryan (2011)
8	**Must contain a variety of SMAs** expressed via game features, corresponding to **all three** basic psychological needs (SDT)	-Theoretical frameworks: PENS, BCTs and the Taxonomy of SMAs in gamification	-Deterding (2011) -Gotsis et al. (2013) -Kato (2012) -Michie et al. (2011, 2013) -Osorio et al. (2012) - Rigby & Ryan (2011)
9	**Provision of educational information about physical activity**	-Grounded in evidence-based behaviour change theories	-Michie et al. (2011, 2013)
10	Must provide **options for users to self-report on physical activity** frequency, time and type	-Grounded in evidence-based behaviour change theories -Necessity for particular game features to function appropriately and to collect research data	-Michie et al. (2011, 2013)
11	Must **have the ability to store physical activity data entered by user** (graphs, charts, tables or text)	-Necessity for particular game features to function appropriately -Necessity for research data collection	[Research team consultation: Stathi, A., Deterding, S. & Medina, E., 2014]

Conroy, Yang and Maher (2014) identified 167 physical activity applications from Apple iTunes and Google Play in August 2013 and coded them according to the CALO-RE taxonomy of BCTs. Most of the applications had fewer than four BCTs present in their designs and Conroy, Yang and Maher (2014) determined that there are two categories of physical activity applications, namely educational and motivational ones. Although the objectives and applied theoretical framework match the strategy of this study more closely than the previously reviewed studies, Conroy, Yang and Maher (2014) do not reveal their final list of applications included in the study and thus the study does not provide helpful opportunities to assist with the selection approach for the *Intervention Implementation Study* (*Study 2*).

Yang, Maher and Conroy (2015) present the most recent available study related to reviewing specifically physical activity mobile applications with the intention of evaluating the representation of BCTs. Yang, Maher and Conroy (2015) utilised the taxonomy of 93 BCTs (see Appendix 3.2) and concluded that on average only 6.6 BCTs were found in the top ranked applications (N = 100). Physical activity applications were searched using the Apple iTunes and Google Play stores using "health and fitness" as the search category within each one. Yang, Maher and Conroy (2015) decided to choose the top 25 paid and free applications from each store, resulting in a total sample of N = 100. Just as in the previous study (Conroy, Yang and Maher, 2014), Yang, Maher and Conroy (2015) did not include the list of applications coded for the purpose of their study; thus, it is unclear which physical activity applications were chosen. Although the approach and theoretical framework employed in Yang, Maher and Conroy (2015) resembles aspects of this research study, Yang, Maher and Conroy's (2015) study is not helpful for the selection strategy as too little is known about the actual applications employed.

The most comprehensive available study, reviewing health and fitness mobile applications, was done by Lister et al. (2014). This study had a broad approach including applications for physical activity and diet with a final total sample of N = 132. Lister et al. (2014) evaluated each application for the ten effective game elements designed by Reeves and Read (2013), the six core components of health gamification and 13 core health behaviour constructs identified from the work of Doshi et al. (2003), Cowan et al. (2013) and Michie et al. (2011). Lister et al. (2014) assert that the chosen six core components of health gamification arose from a review of the current body of literature; however, the choice of such lacked a clear and verified rationale. Results of this study agreed with those of previous studies, namely that very few theoretical behavioural constructs were detected in the sample reviewed (3.8 out of 13). The use of gamification was more readily evident; however, the integration of gamified components was still below 50% (Lister et al., 2014). While this study presented the first attempt to evaluate the integration of components of gamification and health behaviour theory and could potentially provide a usable foundation for the selection of a physical activity application intervention for this study, Lister et al. (2014) did not include the list of selected mobile applications. Numerous attempts to contact Lister et al. via phone, email and social media to explore the possibility of obtaining the list of selected and reviewed applications were unsuccessful.

Middelweerd et al. (2014) set out to study the potential for mobile applications to promote physical activity among adults utilising the taxonomy of 26 BCTs by Abraham and Michie (2008). In May 2013, Middelweerd et al. (2014) discovered that 23,490 health and fitness applications were available via Apple iTunes and 17,756 via Google Play. Unlike the previously reviewed studies, Middelweerd et al. (2014) disclosed and employed a detailed inclusion criteria list in relation to the

selection of applications for their review. Some key criteria employed directly correlate with the inclusion criteria designed for this study (see Table 3.3), namely: (1) must promote physical activity; (2) aimed at apparently healthy adults; and (3) must show feedback coupled with logged statistics and progress information. Further, Middelweerd et al. (2014) clearly state that applications were excluded if they primarily focused on children or on adults with special conditions (e.g. medical conditions), which presents another direct correlation to the criteria articulated for this study. The selected final sample included N = 64 applications, out of which 57 employed some form of BCTs, although on average only five BCTs were represented.

Middelweerd et al. (2014) include a detailed list of all physical activity applications employing BCTs (N = 57) and thus provide the only published work applicable to this study with detailed insight to the final selection of physical activity applications. In addition, the theoretical framework of the taxonomy of 26 BCTs and the approach to inclusion criteria is not contrary to the strategic development of the intervention protocol development for this study. Thus, Middelweerd et al.'s (2014) list of selected mobile physical activity applications will serve as the baseline for the selection of the intervention application for the *Intervention Implementation Study* (Study 2) in Chapter 4.

The complete list of 57 physical activity applications (Middelweerd et al., 2014) can be found in Appendix 3.3. The inclusion criteria (Table 3.3), developed specifically for application in this study, were used to evaluate the 57 physical activity applications. First, inclusion criterion one was applied to all 57 applications (Table 3.4), namely the availability via both widely used operation systems: iOS and Android. This resulted in the deletion of 50 applications, which were available for either only Android or for iOS. The remaining seven applications were then measured against inclusion criterion two, which states that there should not be a charge for their usage. None further were eliminated in this step. Next, inclusion criteria three, four and five were applied, further eliminating five more applications (two based on criterion three, one based on criterion four and two based on criterion five) (Table 3.4).

Only two physical activity applications remained from the original sample of N = 57: (1) Fitocracy and (2) Macaw. It turned out, however, that Macaw was no longer available (i.e. ceased to exist). This is not an uncommon phenomenon in the emerging mobile application market, with many applications leaving the stores as quickly as they emerged. Thus, Fitocracy remained as the only viable physical activity application for further evaluation to determine if this tool would be the appropriate selection for the *Intervention Implementation Study (Study 2).*

Table 3.4: Application of Criteria 1, 2, 3, 4 & 5

	Middelweerd et al. (2014)	**C 1** (iOS & Android)	**C 2** (free)	**C 3** (focus on PA)	**C 4** (no additional equipment)	**C 5** (web- & mobile-based)
Total Sample	N = 57	N = 7	N = 7	N = 5	N = 4	N = 2

Criteria 6 through 11 were applied to Fitocracy. This evaluation revealed that Fitocracy matched all further six criteria (see Table 3.5) established. To determine if Fitocracy clearly matches inclusion criterion eight, Table 3.6 presents in detail how this application corresponds with each newly developed SMA for gamification.

Out of the 14 SMAs, the only one that Fitocracy does not employ in any form is "open-world designs", an element that has been identified to provide perceptions of autonomy within the gamification context (Table 3.2). However, as the inclusion criteria checklist (Table 3.3) states, the selected intervention application must represent opportunities to meet all three basic psychological needs (competence, autonomy and relatedness) as outlined by SDT. Fitocracy does meet this criterion as other SMAs provide these possibilities via different pathways (Table 3.6) within the application.

The intervention selection process in this section depicts a rigorous evaluation and analysis of the current state of research related to the evaluation of existing commercial physical activity applications. It led to the selection of a web- and mobile-based gamefully designed physical activity application (Fitocracy) matching all clearly articulated and carefully designed criteria. Further, Fitocracy employs comprehensive gameful design features as presented through the matching of features to the newly designed taxonomy of SMAs in gamification (Table 3.2). Thus, Fitocracy also has the potential to activate psychological and behavioural outcomes, as mapped in Table 3.2.

Limitations of this selection process include the consistently changing market of commercial physical activity applications and the multitude of available possibly matching applications. It is possible that other physical activity applications exist and were missed in this selection process. As stated in the previous section, ideally an authentically designed web- and mobile-based gamefully designed physical activity application would have presented the best choice for application to *Study 2*. However, that was not feasible based on financial and contextual circumstances. Therefore, choosing an existing commercially available application was a realistic alternative. The next section will provide a detailed overview and description of the selected intervention application (Fitocracy) for the *Intervention Implementation Study (Study 2)* in Chapter 4.

Table 3.5: Application of Criteria 6, 7, 8, 9, 10 & 11 to Fitocracy

Criteria	Fitocracy	Description
C 6 - (PA of choice)	X	Users can participate in any physical activity of their choice including lifestyle-related physical activity and structured physical activity
C 7- (adults)	X	Designed for persons over the age of 18
C 8 - (SMAs)	X	See Table 3.6 for details
C 9 - (educational info)	X	As part of the dashboard, users have the option to click on a button labelled "knowledge", where they can read and learn about health, wellness and fitness-related topics from industry experts
C 10 - (self-report options)	X	User can track their physical activity in the following ways: type, frequency, intensity and time
C 11 - (data storage)	X	Physical activity data is stored under "track" the way it was entered including: type, frequency, intensity and time

Table 3.6: Taxonomy of Situated Motivational Affordances for Gameful Design Applied to Fitocracy

	Situated Motivational Affordances	Theoretical Mediator(s) (SDT-related)	Examples of Supporting Game Features in Fitocracy
1	**Opportunities for Goal Setting**	-Perceptions of competence	-Users have the opportunity to move up to different levels and obtain different badges based on achievements, which allows users to set specific goals -Users can focus on setting goals for general categories or for specific activities (e.g. strength, running, cycling, etc.)
2	**Optimal Challenges**	-Perceptions of competence	-Users can view many available "quests" that present different challenges or varying difficulty levels and choose to participate in as many or as few as they would like to
3	**Cumulative Competence Feedback**	-Perceptions of competence	-Every time users track physical activity, they move towards the next level -Every time users track physical activity, a message is posted on the personal profile page, which assists with improving the reputation among the user's followers -Every time users track physical activity, they earn points -Users can earn badges as a results of tracking physical activity
4	**Sustained Competence Feedback**	-Perceptions of competence	-Fitocracy provides pop-up windows with messages of support and approval immediately upon logging physical activity -Followers can "prop" activities logged, which acts as a virtual applause to a particular action
5	**Granular Competence Feedback**	-Perceptions of competence	-Progress bar -Visual cues for each entry -Rewards (points, badges and levels)
6	**Opportunities for Identity Choice**	-Perceptions of autonomy	-Users can create a personal profile with pictures and names of their choice
7	**Opportunities for Goal Choice**	-Perceptions of autonomy	-Choice of many different quests

Table 3.6 continued: Taxonomy of Situated Motivational Affordances for Gameful Design Applied to Fitocracy

	Situated Motivational Affordances	Theoretical Mediator(s) (SDT-related)	Examples of Supporting Game Features
8	**Opportunities for Action Choice**	-Perceptions of autonomy	-Engage in quests -Participate in groups of interest -Participate in a variety of physical activities and track them -Socialise through “connect” and support others in their physical activity journeys
9	**Open-World Designs**	-Perceptions of autonomy	-Not available within Fitocracy
10	**Opportunities for Acknowledgement**	-Perceptions of relatedness	-Leader boards -Message boards
11	**Opportunities for Support**	-Perceptions of relatedness	-Team play -Friend bar -Starter friend -Pictures of friends greeting you at start of game -Message boards/feedback
12	**Opportunities for Impact**	-Perceptions of relatedness	-Message boards/feedback -Groups -Connecting/friends
13	**Cooperation**	-Perceptions of relatedness -Perceptions of autonomy -Perceptions of competence	-Gathering friends into groups
14	**Competitive Play**	-Perceptions of relatedness -Perception of competence	-Leader boards -Quests -Groups -Competition (for an additional fee: “Fitocracy Hero”)

3.4.3 Selected Intervention Application Description

Fitocracy is a web- and mobile-based gamefully designed physical activity application with the intention of improving health and fitness while having fun. According to its website (https://www.fitocracy.com), Fitocracy was developed in 2010 after one of its founders, Richard Talens, had the idea to turn fitness into a game. He and his friend, co-founder Brian Wang, both comprehended how elements of physical activity and fitness can be addictive, such as getting to the next level, beating someone or completing a particular challenge. They decided that the addiction that drove their fitness efforts was the same addiction that games create. The mission of Fitocracy is to add more fun to fitness for a more addictive experience (Fitocracy, 2013).

Fitocracy was launched in February 2011. Fitocracy is delivered via a web-based application (https://www.fitocracy.com) and is accessible via a mobile-based application for both iOS and Android. Both are complimentary to their users, although some upgrade options within the application for an extra charge exist, but are not necessary. In addition, Fitocracy is connected to the following social media sites: *Twitter, Facebook, Google+, Pinterest, Tumblr, Instagram and Spreadshirt,* a fact that expands the social connectedness capability of this application. It was specifically developed for persons over the age of 18. Users of Fitocracy can choose to engage in physical activity of their choice, whether it is lifestyle-related physical activity or planned, structured physical activity. The tracking option allows Fitocracy users to track the frequency, intensity, time and type of all physical activity via self-report options and it stores this data under the personal profile that is required prior to being able to use Fitocracy.

Fitocracy features a simplistic layout with numerous SMAs expressed in various game feature options, immediately visible to the user. Table 3.7 shows the available options in the primary navigation bar on the personal profile page.

Table 3.7: Fitocracy Game Features in Primary Navigation Bar

The Feed	*Posting, commenting, props, inviting friends*
You	*About me, feed, friends, groups, achievements, quests, performance*
Track	*Tracking a workout, finding activities, points, levels*
Knowledge	*Knowledge, resources*
Leaders	*Spotlight of the month, navigation and filters*
Connect	*Fitness interest, type, general interest, gender, your groups, create a group*
Search Bar	*Search the website*
The Dashboard	*Personal information page that displays your personal information*
Notifications	*The system generates notifications and messages to your email or phone*

Source: Fitocracy (2016)

The following screenshots (Figures 3.4 through 3.15) provide a visual presentation of examples of the various game features providing situated motivational affordances within this application for each user. The examples chosen here for exhibition correspond with Table 3.7; however, they do not exclusively represent all situated motivational affordances available within the application. For a comprehensive list of SMAs within Fitocracy, refer to Table 3.6.

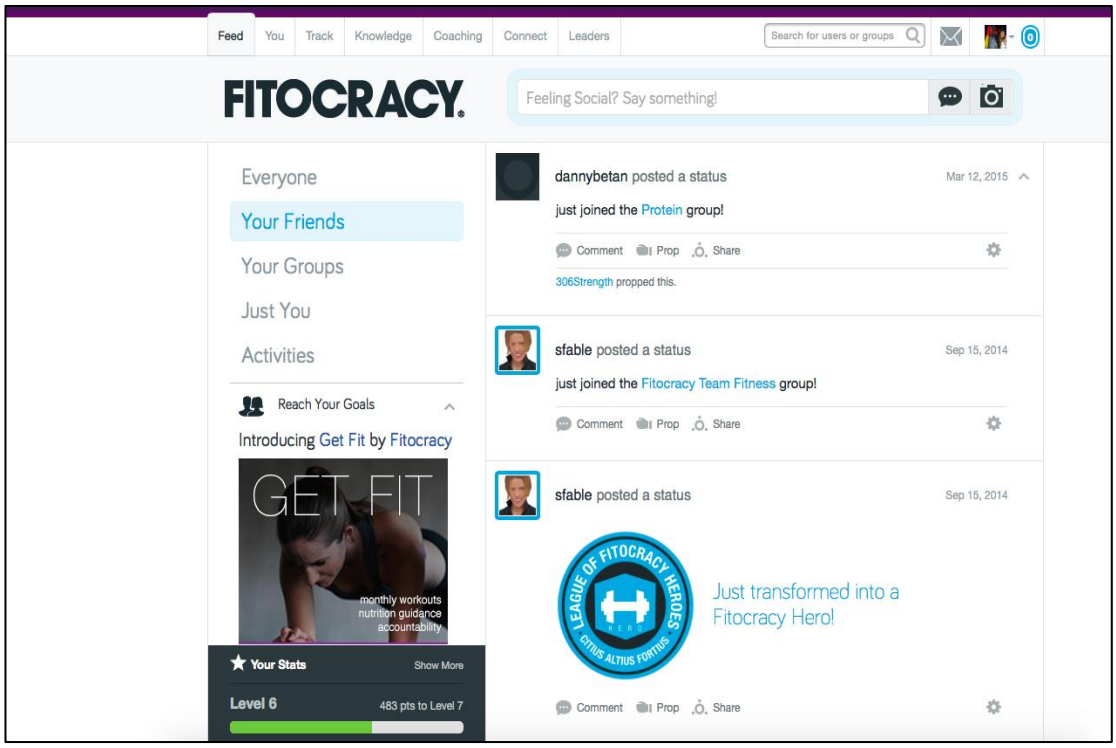


Figure 3.4: The Feed Exhibit

When a person decides to sign up for Fitocracy, the system will guide each step of the way via messages. A little robot mascot (Fred) assists with the set-up of the personal profile. The person can choose their screen name and post an image of their choice to create their identity. The personal profile with personal dashboard (Figure 3.5 and 3.15) will display the level that you have achieved on Fitocracy, the total number of points you have earned for physical activity, how many followers you have, your age and your gender.

Once the personal profile is established, the system will automatically explore your interests by introducing you to groups (Figure 3.14) that exist within Fitocracy, which you can choose to belong to. An example of such a group is: Martial Arts. Many options exist, so that everyone can find a group(s) of their choice. If a particular group does not exist, the participant can start a new group centred on their activity of choice.

The idea is that each day, you go to the “track” option (Figure 3.6) to track the physical activities that you complete. The system is set up to give you points for the type, time and intensity that you enter (Figure 3.7). Once you have entered any physical activity, the system will provide positive feedback via statements such as: “I’m awesome” or others (Figure 3.7). A certain number of points will get you to the next level and in the process you can earn badges and awards (Figures 3.8 and 3.9). The system shows you exactly what your status and progress are via points and graphs (Figure 3.10).

To provide a number of gamefully designed options for the participants, people can choose to connect with “friends” on the network, join groups, create groups, participate in challenges or quests and earn points (Figure 3.5 sidebar). There are a variety of leader boards (Figure 3.13) that can be accessed in order to view who is doing well and potentially see oneself on one of them. Badges and awards are a big part of making progress with Fitocracy. Feedback is also provided via a variety of ways. One of the ways you can get feedback is from friends and

connections. People can post messages on your wall and also give you “props” for entering workouts and physical activity. Once any activity occurs on your profile, you will be notified automatically via email and/or text message.

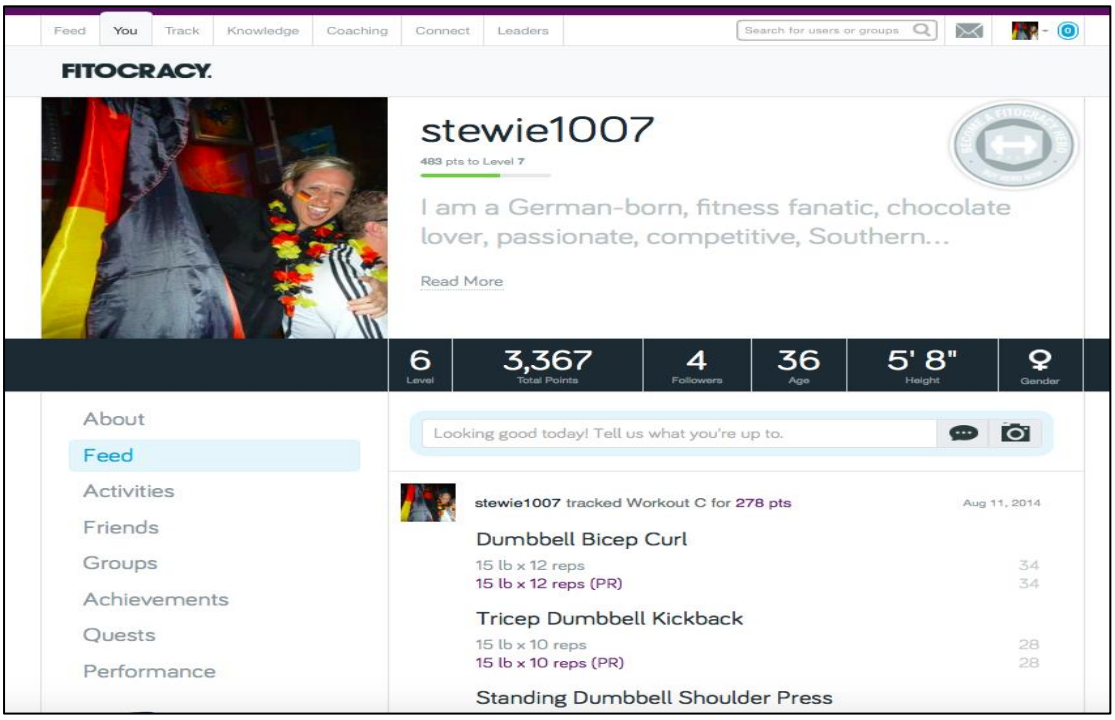


Figure 3.5: You Exhibit

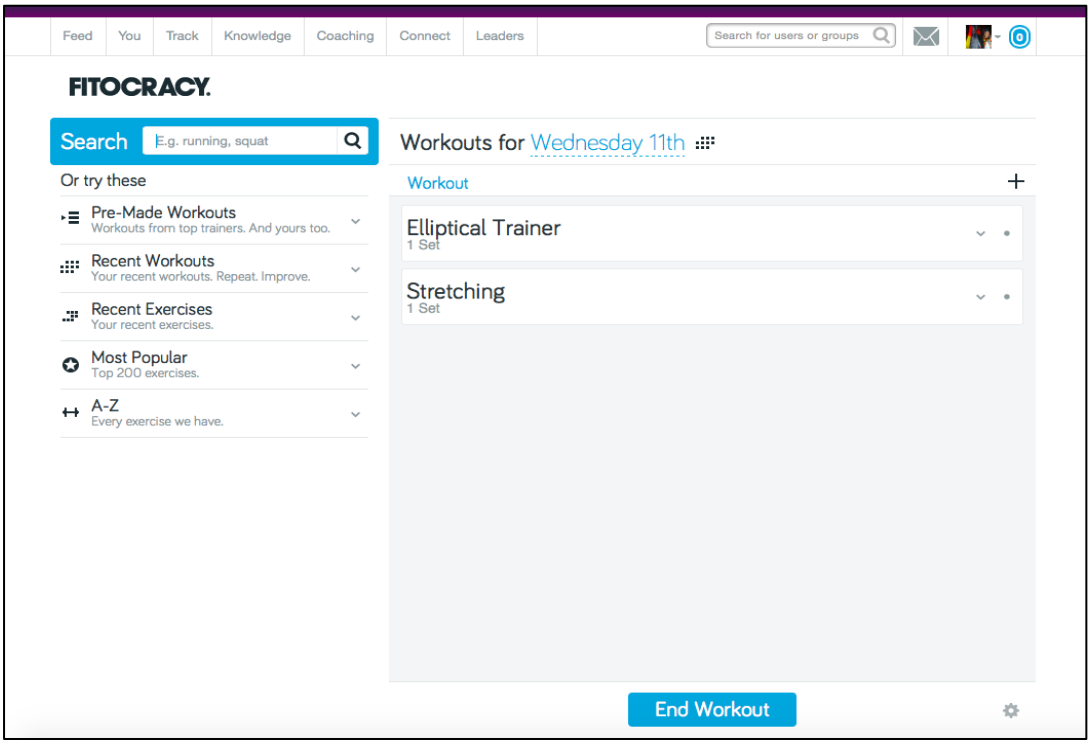


Figure 3.6: Track Exhibit

Another resource is the “knowledge” tab (Figures 3.11 and 3.12). This option provides participants with helpful articles, blogs and information about health and fitness. The Fitness Ambassadors are the contributors to this section and are well-known health, fitness and nutrition experts.

The key element of Fitocracy is the community. Participants are referred to as “Fitocrats” and the entire experience is framed by the notion that you are now part of a close community that cares about each others’ fitness journey. The social features are quite extensive, and according to the founders, the reason why people stay with Fitocracy is because of the community (Fitocracy, 2013). According to Werbach and Hunter (2012), Fitocracy is a great example of applying SDT to a gamefully designed site to increase intrinsic motivation.

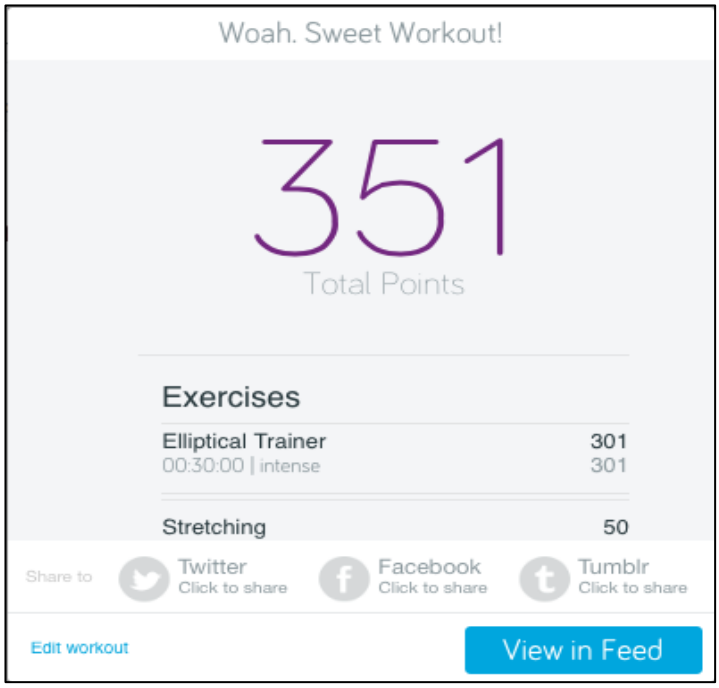


Figure 3.7: Feedback Exhibit 1

Figure 3.8: Feedback Exhibit 2

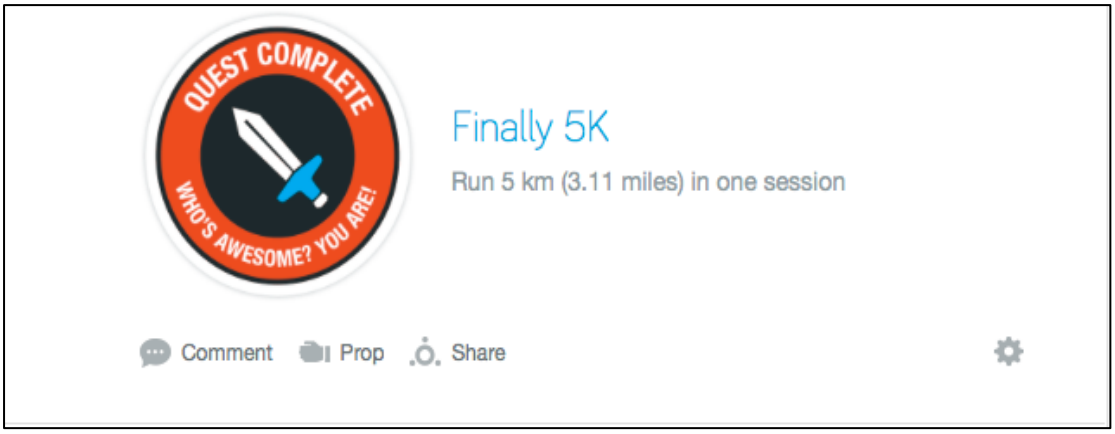


Figure 3.9: Feedback Exhibit 3

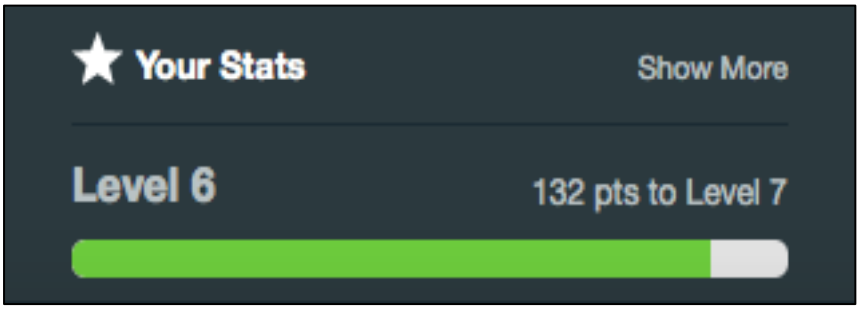


Figure 3.10: Feedback Exhibit 4

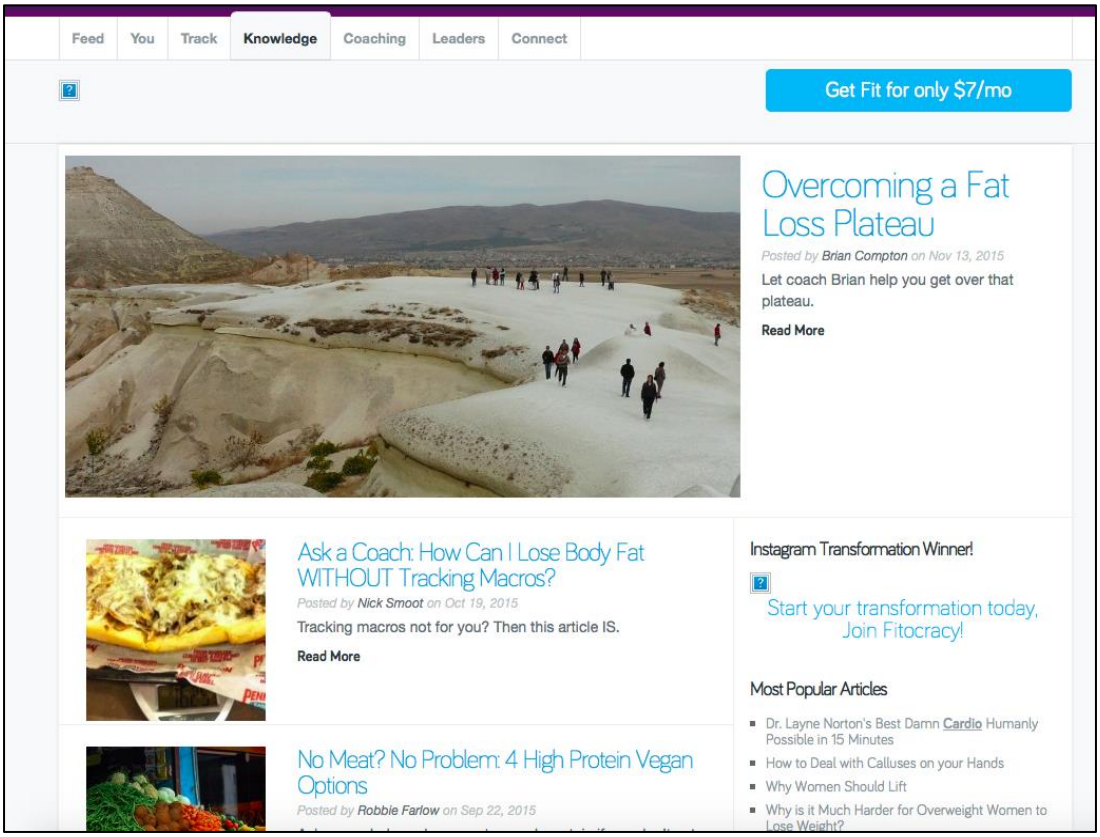


Figure 3.11: Knowledge Exhibit 1

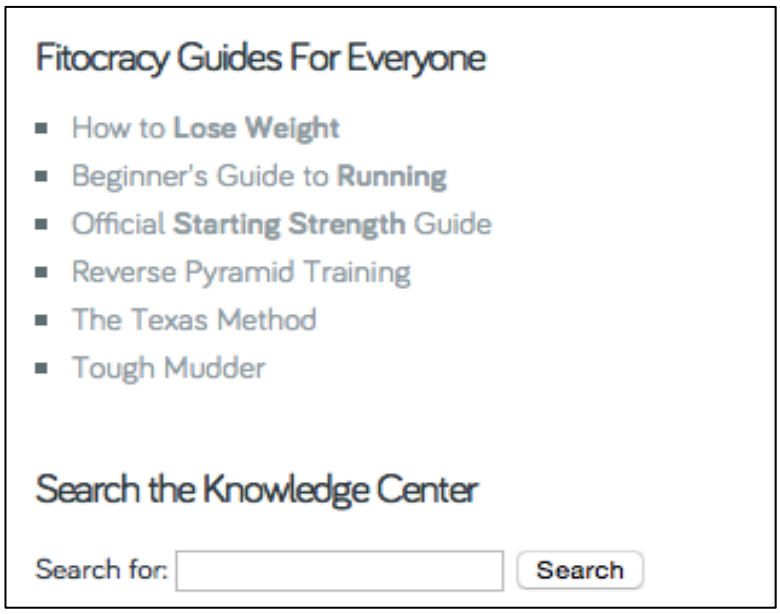


Figure 3.12: Knowledge Exhibit 2

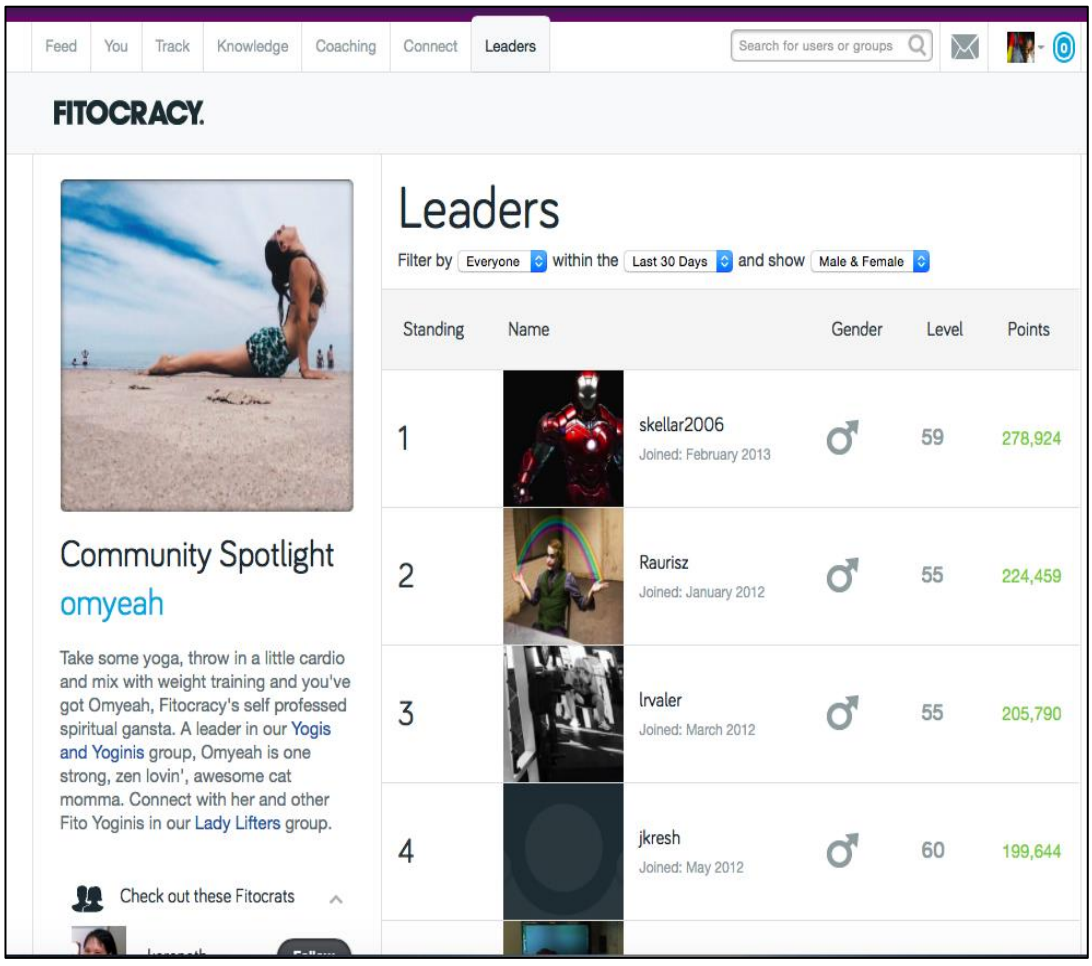


Figure 3.13: Leaders Exhibit

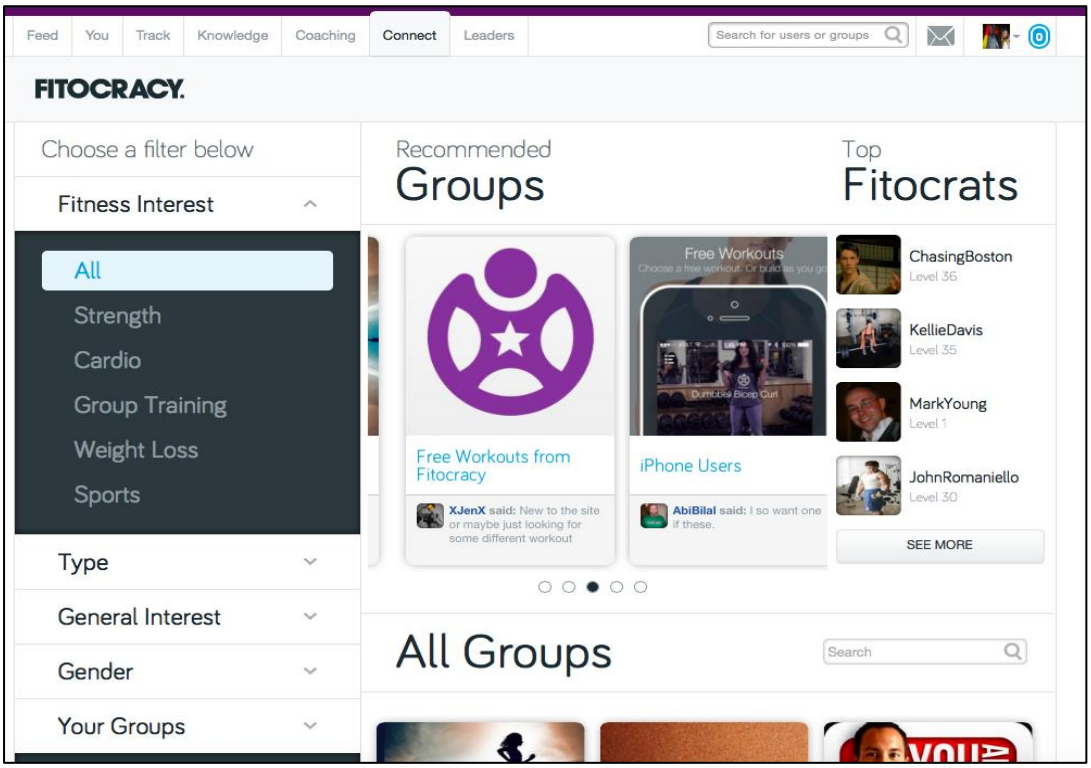


Figure 3.14: Connect Exhibit

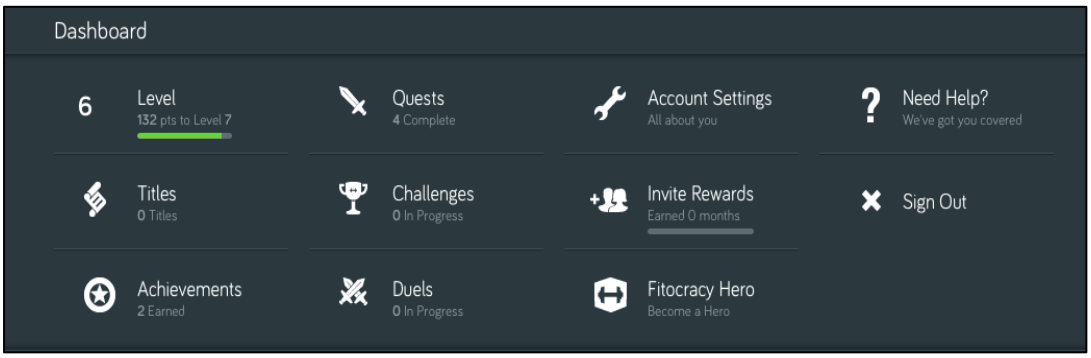


Figure 3.15: Dashboard Exhibit

3.5 Summary

Applying IM strategies, Chapter 3 of this thesis presented in detail steps three and four of the model. Chapter 2 provided important theoretical bases corresponding to step one of the IM model (needs assessment), guiding the process of further exploration of theoretical framework connections and ultimately leading to the novel development of a new *Taxonomy of Situated Motivational Affordances in Gamification*. The study design in this chapter was expressed in a strategic three-stage research process model for logical mapping and navigating through the various interdisciplinary subject areas.

The creation of the new taxonomy laid a new layer within the foundation of the understanding of the potentially interrelated concepts of gamification, motivation and behavioural outcomes in relation to physical activity behaviour. Further, the detailed evaluation of the current landscape of research of health and fitness

applications within computing technology assisted in the establishment of an inclusion criteria checklist for the selection of an appropriate intervention for *Study 2*.

The result of the detailed journey through the three-stage research process model resulted in the selection of an intervention application: Fitocracy. Although it would have been ideal to design an authentic new research application for the purpose of the intervention in *Study 2*, selecting an existing commercial gamified physical activity application was an appropriate alternative option, and it also provided the potential of further reach to a greater number of people beyond this particular research study.

Study 1 represents a comprehensive interdisciplinary approach to develop a gamefully designed physical activity intervention grounded in evidence-based theory, built directly on an applicable integrated theoretical framework. Helf and Hlavacs (2016) verify that IM is a complementary approach to creating health-related interventions and provides potentially the first step to integrating theoretical concepts in relation to gamification, health and behaviour change, particularly in the context of the architectural design of applications within computing technology. Further, *Study 1* contributed two key novel developments to the current field in research: (1) the development of a *Taxonomy of Situated Motivational Affordances in Gamification*, specifically in connection to theoretical mediators of psychological and behavioural constructs; and (2) the creation of an inclusion criteria checklist for the selection of a gamefully designed physical activity application for the purpose of an intervention study. Although the inclusion criteria checklist was specifically designed for this PhD study, it has potential for adaptation to future research in a variety of health-behaviour contexts.

CHAPTER 4: STUDY 2 – INTERVENTION IMPLEMENTATION EXAMPLE CASE

4.1 Intervention Protocol for *Study 2*

4.1.1 Introduction

Physical activity positively promotes overall health and a higher quality of life. It can prevent the development of chronic disease and provides a plethora of advantageous benefits for human beings (USDHHS, 2008). Unfortunately, physical inactivity and sedentary behaviour have been observed particularly in the Western world, with 3.2 million lives lost per year worldwide (Lim et al., 2012). In the United States, it appears that the onset of a rapid decrease of physical activity level starts in the mid-twenties, whilst technology usage and gameplay are at the highest in the age group of 25 to 44 (IDC, 2013; ESA, 2010).

One solution to address the aforementioned health concern of physical inactivity is to provide motivation for physical activity. Previous research shows that motivation can positively impact physical activity behaviour and that SDT is a well-validated theory for understanding and driving physical activity motivation (Teixeira et al., 2012). The concept of gameful design has the potential to be an effective tool in turning physical activity into a more enjoyable experience and meeting the basic psychological needs of autonomy, competence and relatedness in many, leading to increased self-determined behaviour, which motivates people to engage in physical activity (Schlagenhaufer & Amberg, 2014). However, this assumption requires further validation from well-designed, theory-grounded research (Kato, 2012). Thus, an SDT-based physical activity intervention provides an opportunity to expand knowledge in relation to effective methods in this field as showcased in *Study 1.*

The review of literature (Chapter 2) led to the discovery of several significant gaps within the current research landscape related to gameful design, motivation and physical activity behaviour. A key issue is the lack of usage of evidence-based theories and of frameworks that might tie together the various aforementioned principles (Kato, 2012). This lack has resulted in poor methodological research design and a dearth of evidence related to the effectiveness of gamefully designed principles tied to motivation for physical activity. Thus, there are tremendous opportunities to fill the gaps with further research, yielding the recommendations to link theory to methodology and to practical implementation.

Study 1 (see Chapter 3) provided a detailed systematic approach to building a theoretical foundation of gameful design in relation to physical activity behaviour change, resulting in the development of a new *Taxonomy of SMAs for Gameful Design.* This taxonomy strategically linked its identified elements to theoretical mediators (SDT and BCTs), providing practical pathways for selecting an appropriate web- and mobile-based application for *Study 2*. After a careful strategic review, Fitocracy was chosen as the intervention application for *Study 2*.

Study 2, the *Intervention Implementation Example Case Study,* is the result of the identification of the main determinant (physical inactivity), the conclusions drawn from current literature (promise of SDT and gameful design principles in relation to motivation and physical activity) and the gaps therein (lack of interdisciplinary theoretical framework application, absence of strategic methodological approach and lack of rigorous research methods and practices). The IM design approach

has provided a systematic pathway for linking theory and evidence with an intervention implementation case example. *Study 2* employs steps two, four, five and six of the IM approach and is presented in its entirety in this chapter.

First, specific aims, objectives, hypotheses and outcomes will be stated as indicated in step two of IM. Second, step four of IM entails the development of an appropriate program protocol, which resulted in the design of the detailed methods of the intervention protocol for *Study 2*. Further, it included the development of all protocol materials. Third, step five of IM focuses on the implementation process of the selected intervention. Lastly, step six of the IM approach asserts a comprehensive evaluation process of all aspects of the program implementation. The evaluation of variables will be described in detail in this chapter leading to an overall evaluation study, *Study 3* (Chapter 5).

4.1.2 Aims and Objectives

The main aim of this intervention was to assess the effectiveness of a theory-linked, web-based, gamefully designed physical activity intervention on the physical activity levels of sedentary adults as measured at six weeks, three months and six months. The secondary aim of this intervention was to establish a link between self-determined motivation for physical activity and effectiveness of gameful applications over periods of six weeks, three months and six months.

Four specific objectives were formulated to systematically achieve the aforementioned aims:

1. To implement and evaluate the impact of a web-based, gamefully designed physical activity application on moderate-to-vigorous physical activity (MVPA) levels of sedentary adults at baseline, six weeks, three months and six months.

2. To assess the impact of a web-based, gamefully designed physical activity application on the mediating outcome of internalised motivation measured at baseline, six weeks, three months and six months.

3. To estimate the variance in the primary outcome to inform sample size calculations for a definitive randomised controlled trial.

4. To evaluate the effects of increased intrinsic motivation on levels of physical activity.

4.1.3 Research Design

This study is a single-centre exploratory randomised controlled trial pilot example case study comparing an intervention and control condition over a six-week period with a three- and six-month follow-up. Three hypotheses were developed for this study:

Primary Hypothesis: Sedentary adults who participate in a six-week web-based gamefully designed physical activity intervention will increase their physical activity levels measured at six weeks, three months and six months.

Secondary Hypothesis: Sedentary adults who participate in a six-week web-based gamefully designed physical activity intervention will show increased internalised motivation for physical activity measured at six weeks, three months and six months.

Tertiary Hypothesis: Increased internalised motivation for physical activity will mediate the effect of a gameful intervention on maintenance of increased physical activity at six weeks, three months and six months post-intervention compared with baseline values and compared to the control group.

4.1.3.1 Randomisation
Eligible participants were randomly assigned to either the intervention or the control group using a web-based randomisation service (Research Randomizer). The online programme was programmed to utilise a two-to-one allocation randomisation sequence without any further specifications.

4.1.3.2 Addressing Sources of Bias
This research design entailed a rolling enrolment approach, thus participants were randomly allocated to either the intervention or control group immediately upon successful enrolment in the study. All efforts were made to conceal group allocation from study participants throughout the entirety of the study, although complete blinding in behavioural intervention studies is rarely possible. The research team could not be blinded to group allocation of participants as each group followed a different appointment protocol, executed by the research team. Each staff member was specifically trained and instructed to not reveal group allocation to the participant during any of the interactions and data collection. Due to the focused geographical area of recruitment, contamination between participants cannot be completely ruled out; however, it is unlikely that this occurred.

4.2 Methods

4.2.1 Study Population
The aim was to target the general population in the Inland Empire (IE) of Southern California, selecting participants based on the inclusion and exclusion criteria (see Table 4.1). These were established considering parameters related to age group, safety, standards of practice and practicality for the purpose of this intervention context. The inclusion and exclusion criteria were clearly articulated on all recruitment materials, thus ensuring complete transparency from the outset to all prospective participants.

Sedentary adults ages 25 to 44 years willing to participate and to commit to a six-month study period were sought for participation in the study. To determine the inclusion of participants in this study, the following screening measures were selected:

1. International Physical Activity Questionnaire (IPAQ) seven-day short version (see Appendix 4.1)

2. Questionnaire on personal data/information *(age, height, weight, BMI, medical conditions, ability to walk across the room with two legs, ability to read and write, ability to use the computer/Internet/smartphone, availability of daily Internet access, ability to commit to the time frame of entire study, ability to come to the study centre on several occasions)* (see Appendix 4.2)

3. Physical Activity Readiness Questionnaire (PAR-Q) (see Appendix 4.3)

All three items were combined and delivered via a screening questionnaire (SurveyMonkey) online that had to be completed by all potential research participants. Access to the Internet via a personal computing device and ability to get to the study centre were requirements for inclusion. Further, participants had to be able to walk across the room with two legs and to read and write.

Table 4.1: Inclusion and Exclusion Criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
▪ Adults aged 25 - 44 at the time of enrolment in the study ▪ Sedentary: -As determined by the IPAQ -Engaged in no other cardiovascular, muscular strength or endurance activities on a regular basis ▪ Willing to participate voluntarily ▪ Cleared to participate in physical activity (PAR-Q and medical clearance if necessary) ▪ Physically able to walk with two legs across the room ▪ Able to read and write ▪ Able to access the Internet daily via either computer or smartphone ▪ BMI under 40 ▪ Ability to commit for the time frame of six months plus one appointment post-six months (between 1 – 3 months after completion of six months) ▪ Ability to come to the study centre ten times on specific dates during the study	▪ Medical condition that would prevent participation in the simplest form of physical activity: walking ▪ Answered more than one question with 'yes' on the PAR-Q and cannot produce a medical clearance form ▪ Participants who cannot commit to the duration and requirements of the study ▪ Participants who do not have access to the Internet or a smartphone on a daily basis

4.2.2 Data Collection

The primary outcome for this research intervention was set on change in minutes of MVPA per day at four different time points for a seven-day period each: baseline, six weeks, three months and six months (see Table 4.2). Wrist-worn, validated accelerometers (GENEActiv) were used, providing high compliance rates and minimal inconvenience to participants, as they were waterproof, allowing showering and other daily tasks associated with water. Participants were asked to wear the accelerometer seven days prior to the intervention for baseline data collection, seven days immediately post-intervention (six weeks), seven days after three months of initial start of the intervention and seven days after six months of the initial start of the intervention. At the conclusion of each of the seven-day periods, participants returned the accelerometer to the study centre for immediate uploading of the data to the appropriate accelerometer-corresponding software. Data obtained was then extracted to data collection sheets for the purpose of analysis utilising the Statistical Analysis System (SAS).

The secondary mediating outcome was to evaluate theoretical linkage of intrinsic motivation for physical activity. Two different validated measures were employed at baseline, six weeks, three months and six months (see Table 4.2): (1) the Behavioural Regulation of Exercise Questionnaire (BREQ-2) (Markland & Tobin, 2004) (see Appendix 4.14) and (2) the Intrinsic Motivation Inventory (IMI) (validated by MacAuley, Duncan & Tammen, 1989) (see Appendix 4.15).

The first questionnaire, the BREQ-2, is a measurement tool of the continuum of self-determination developed by David Markland at the University of Wales, Bangor. The scoring system for this questionnaire can be multidimensional or unidimensional (see Appendix 4.14), and it assesses the degree of self-determination in relation to physical activity (Ryan & Connell, 1989). Moreno, Gimeno and Camacho validated the BREQ-2 with a study in 2007.

The second questionnaire, the IMI, is a questionnaire and measurement tool assessing the subjective experience related to a particular target activity in laboratory experiments. In this case, physical activity was the activity of choice. There are multiple subscales of measurement; however, the only one actually assessing intrinsic motivation is the one called the "interest/enjoyment" subscale. To score this instrument, first items indicated by (R) must be reversed (see Appendix 4.15). The item response from eight must be subtracted and the resulting number used as item score. Subscale scores are calculated by averaging across all of the items on that subscale. The subscale scores are then used in the analyses of relevant questions. MacAuley, Duncan and Tammen validated the IMI with a study in 1989.

The BREQ-2 and IMI questionnaires were combined and made available electronically with the assistance of the Research Consulting Group at Loma Linda University. Each participant was asked to complete these questionnaires before the intervention, immediately after the intervention, three months after initial start of the intervention and again six months after initial start of the intervention. The data from the surveys was extracted to data collection sheets for the purpose of evaluation utilising the SAS.

Basic biometric data was collected at the study centre prior to the intervention, immediately after the intervention, three months after initial start of the intervention and six months after initial start of the intervention (see Table 4.2). This data included: height, weight, body fat percentage and BMI as measured by Biospace (see Appendix 4.11 & 4.12) equipment.

4.2.3 Ethics Approval

Prior to the recruitment and beginning of the study, human subjects approval was obtained from the Internal Review Board (IRB) at Loma Linda University (LLU), La Sierra University (the primary investigator's employer at the time of the data collection) and the University of Bath Ethics Committee (REACH). The Southeastern California Conference of Seventh-day Adventists does not have an ethics committee; however, this study was required to go through their executive committee for approval. All entities approved the study (see Appendices 4.16, 4.17 & 4.18).

4.2.4 Data Handling

Research participants were advised that if any adverse events occurred they should contact the primary investigator immediately, so that it could be determined whether this individual would have to drop out of the study. In such

cases, it was noted in the data collection database that participant X did not complete the study or that data had to be excluded.

It was expected that each participant be present for the various data collection sessions. If any participants did not attend these required meetings, research staff contacted them immediately to acquire a reason and then determined if another time could be rescheduled for that participant without compromising the data. If so, arrangements were made.

Participant information sheets and informed consent forms were completed accordingly prior to any data collection (see Appendix 4.22). All data was stored in password-protected and secured systems exclusively and participants' information has remained strictly confidential. All aspects of the execution of this study were in compliance with IRB regulations at LLU and long-term data storage has been completed accordingly.

Table 4.2: Measures

Measures	Baseline	6 Weeks	3 Months	6 Months
MVPA measured in minutes per day using accelerometers (GENEActiv) (see Appendix 4.13)	X	X	X	X
Behavioral Regulation of Exercise Questionnaire (BREQ-2) *-Modification: the term "exercise" will be changed to "physical activity" in this questionnaire for the purpose of this study* *-RAI measures the degree to which respondents feel self-determined* *-The BREQ-2 multidimensional scoring measures five separate items: amotivation, external regulation, introjected regulation, identified regulation, intrinsic regulation*	X	X	X	X
Intrinsic Motivation Inventory (IMI) *-Modification: the full 45 items from seven subscales will be adapted for the target activity: physical activity* *-The IMI assesses participants' subjective experience related to physical activity* *-The IMI subscales measure the following items: interest/enjoyment, perceived competence, effort/importance, pressure/tension, perceived choice, value/usefulness and relatedness*	X	X	X	X
Lab-measured height, weight, Body Mass Index (BMI) and body composition (bioelectrical impedance analysis (BIA)) (Biospace) (see Appendix 4.11 & 4.12)	X	X	X	X

4.2.5 Research Team

The research team on site consisted of the primary investigator (the author), the field-based supervisor and eight additional research assistants specifically recruited for the execution of this research intervention (see Appendix 4.20 for details on each research assistant). Four of the research assistants were professionals within the health field interested in gaining further experience in research skills obtained through a randomised controlled trial. Two of these professionals were assistant professors of Health and Exercise Science at La Sierra University, one was the project manager of the Wholeness Institute at Loma Linda University and one was a nurse at the LLU Medical Center. Three of the research assistants were undergraduate students in the Department of Health and Exercise Science at La Sierra University and one research assistant was a graduate student in the Department of Orthotics and Prosthetics at LLU.

The research team had to go through thorough training, including the Human Subjects Education (see Appendix 4.21) course provided by the IRB at LLU. Each research team member had to conduct a minimum of three supervised practical demonstrations before being allowed to collect data independently or interact with research participants.

Further, each research team member had to go through detailed technological training in relation to the accelerometer devices, software utilised and websites where the various online questionnaires were housed. Quality control was ensured by daily communication and reporting mechanisms of research team members to the primary investigator.

4.2.6 Location

This study was conducted in partnership with the Center for Nutrition, Healthy Lifestyle and Disease Prevention at LLU in the School of Public Health (see Appendix 4.19 for agreement evidence). This partnership provided access to a laboratory space for data collection in the Preventive Care Clinic at the Drayson Center on the campus of LLU, which is sponsored by the above-mentioned centre. The assigned laboratory space will be referred to as the study centre for the purpose of this research study.

The study centre was equipped with all necessary tools to conduct the data collection. Further, data was securely stored in the study centre and the location was easily accessible for the research team and the research participants.

4.2.7 Sample Size Calculations

In order to conduct a proper analysis of the data collected, the following sample size calculations were done with the assistance of a professional statistician at LLU. Since this study is the first of its kind, directly related research concerning protocol was unavailable; only research somewhat related to this protocol could be utilised to inform sample size calculations. Thus, the following represents an estimate.

Sample size was calculated for a two-sample *t*-test on the difference of $Y_{post} - Y_{pre}$, where Y denotes time (minutes/day) in moderate-to-vigorous physical activity (MVPA) at the baseline or after the intervention. Wijsman et al. (2013) showed that in their three-month web-based intervention trial the mean baseline measurements of MVPA were approximately 14 to 17 minutes per day among inactive older adults aged 60 to 70 years. This intervention employed the Internet program *Philips DirectLife*, which included the usage of accelerometers to monitor

physical activity levels and to provide feedback to participants. Further, digital coaching was provided, which gave regular updates and advice.

Another web-based intervention study (12 months) by Carlson et al. (2012) showed the median MVPA of approximately 22 to 24 minutes per day among subjects aged 18 to 56 years. This baseline MVPA level is comparable to a population-based estimate (22.8 minutes per day) from the NHANES 2005-2006 study (Schuna, Johnson & Tudor-Locke, 2013). Components of the web-based intervention by Carlson et al. (2012) included monthly web-based activities, such as learning about new behavioural skills and reporting progress towards goals (set weekly). The system also provided regular feedback via visual graphs and study counsellors called female participants monthly (males were called every three months).

Considering our target population of sedentary adults (ages 25–44), we used 20 minutes per day as an estimate of baseline MVPA. For the effectiveness of intervention, a meta-analysis by Davies et al. (2012) revealed that the overall effect size of physical activity was 0.14 across 25 web-based intervention studies. Assuming the standard deviation (SD) of 15 minutes per day for MVPA, this relatively small effect size corresponds to an increase of approximately two minutes per day. However, Davies et al.'s (2012) analysis included studies that had various intervention lengths (ranges from 2 to 52 weeks) and different methods of measuring physical activity. More relevant to our study design, Wijsman et al.'s (2013) study showed an increase of 11 minutes per day in MVPA (measured by an accelerometer) after a three-month intervention.

Based on these past studies, in order to obtain a conservative estimate of sample size, we assumed a mean increase of 10 minutes per day for the intervention group. For the control group, we assumed no changes in MVPA.

For sample size calculations, we have made the following assumptions: 1) the outcome is normally distributed; 2) its standard deviations are equal between the two groups and remain constant over time; 3) allocation ratio of subjects is two to one (to maximize the number of participants in the intervention group); 4) there is a drop-out rate of 30% in both groups; and 5) a correlation exists of 0.7 between the baseline and three-month measurements of MVPA. For power of 80% and type I error of 0.05 (two-tailed), this resulted in a required sample size of $n = 87$ to detect a difference of 10 minutes per day in MVPA between the two groups after a three-month intervention, assuming a common SD (SD in difference) of 20 minutes per day. After adjusting for a 30% dropout rate, the total sample size required is $n = 124$ (see Appendix 4.4)

These power calculations have been done as a result of existing research available focused on web-based physical activity interventions not containing specific gamified elements, as these hardly exist. Since the design of this thesis includes a detailed process evaluation of this intervention, lessons will be learned pertaining to actual recruitment rates, participation rates, peak times of participation, dropout rates and variance.

4.2.8 Recruitment, Enrolment and Sample

Participants were recruited through LLU, La Sierra University and local churches in the IE of Southern California. This location was chosen due to matters of practicality, resources and available research staff. As outlined in the estimated sample size calculations, to accommodate for a 30% dropout rate, a full sample of 124 was sought.

Recruitment began on September 7th, 2014 and continued through May 28th, 2015, for a total of eight months and 21 days. The decision for the recruitment period was made after all resources, efforts and finances had been exhausted for this research study and no new interested individuals took the online screening survey after a period of six weeks. Many various recruitment methods were utilised to target the age group selected for inclusion in this study. These methods included: email notifications, a webpage, social media (Facebook and Twitter), posters, fliers and verbal announcements. Further, I, as the primary investigator of this study, was invited to present on various topics related to physical activity and to share about the study, which allowed for further recruitment opportunity. Enrolment in the study was voluntary. A detailed account of all recruitment efforts can be found in Appendix 4.5.

Enrolment in this study was rolling, thus, as soon as participants applied, they were screened and approved, then randomly assigned to either the control or the intervention group at a two-to-one ratio. A total of 119 individuals completed the online screening, out of which 19 did not qualify and 17 chose not to enrol even after qualifying. Two individuals were unclear and were contacted by the researcher; however, they never returned the inquiry, and thus remained pending.

A total of 83 individuals enrolled in the study. Immediately after enrolment, an error was detected regarding the screening related to Body Mass Index (BMI) and six participants had to be asked to drop out of the study due to a BMI above 40. Over the course of the study, which began with the first appointment of the first participant on September 15, 2014 and ended on December 8, 2015, nine participants dropped out of the study, leaving 68 active participants remaining (see Appendix 4.10). Out of the nine dropouts, two sustained serious injuries preventing them from being active for long periods of time and one participant moved out of the area, not allowing this individual to complete the required research protocol. The other six dropouts did not provide a reason for dropping out.

The initial sample for this study consisted of 83 individuals with a mean age of 33.6 in the control group and 34.6 in the intervention group (see Table 4.3). Table 4.3 shows the demographics and anthropometrics of participants at baseline by group. These characteristics were compared. For gender, a chi-square test for independence was utilised to detect any significant differences regarding gender proportions. Out of the 83 participants, 57.83% were female (control N=17, intervention N=31). For all other variables (age, weight, BMI, body fat percentage and MVPA), two sample tests were conducted to examine variations at baseline. No significant differences were found between the two groups; however, weight, BMI and MVPA tended to be greater among the control group subjects (p=0.08, 0.08 and 0.11) (see Table 4.3). At baseline, participants in the intervention group weighed 8.9 kg less on average than in the control group. Respectively, BMI was 2.8 points higher in the control group than the intervention group and the body fat percentage was 1.6% higher on average in the control group than in the intervention group.

Table 4.3: Participant Demographics and Anthropometrics at Baseline

Variable		Control (n=26)	Intervention (n=43)	P-value	
Female	n (%)	17 (65.4)	31 (72.1)	0.56	a
Age	mean (SD)	33.6 (6.2)	34.6 (6.5)	0.53	b
Weight (kg)	mean (SD)	80.2 (21.8)	71.1 (18.3)	0.08	b
BMI (kg/m^2)	mean (SD)	28.3 (6.8)	25.5 (5.1)	0.08	b
Body fat (%)	mean (SD)	34.3 (10.4)	32.7 (8.2)	0.49	b
MVPA (min/day)	mean (SD)	153 (60)	132 (46)	0.11	b

MVPA: Moderate and vigorous physical acitivity (min/day) measured by ….

a: P-value from chi-square test for independence

b: P-value from two-sample t-test

4.3 Intervention Implementation

The implementation of the intervention protocol for *Study 2* resulted in an 18-month undertaking (see Table 4.4). It included the preparation, approvals, training, recruitment, enrolment and the actual data collection processes. Table 4.4 indicates the specific time frame and total amount of time for each component as it was recorded for this study.

Table 4.4: Summary of Implementation Phases

What	Time Frame	TOTAL
Preparation & Approvals	June – August 2014	3 months
Training of Research Assistants	July & August 2014	2 months
Recruitment & Enrolment	September 2014 – May 2015	9 months
Data Collection	September 2014 - December 2015	15 months
TOTAL LENGTH OF IMPLEMENTATION FOR STUDY 2		**18 months**

Figure 4.1 outlines the detailed flow of the entire research process. Specific time frame details pertaining to each research appointment are included, providing a clear overview of the different phases of research in this study. Data for the intervention and control group was collected at baseline, six weeks, three months and six months.

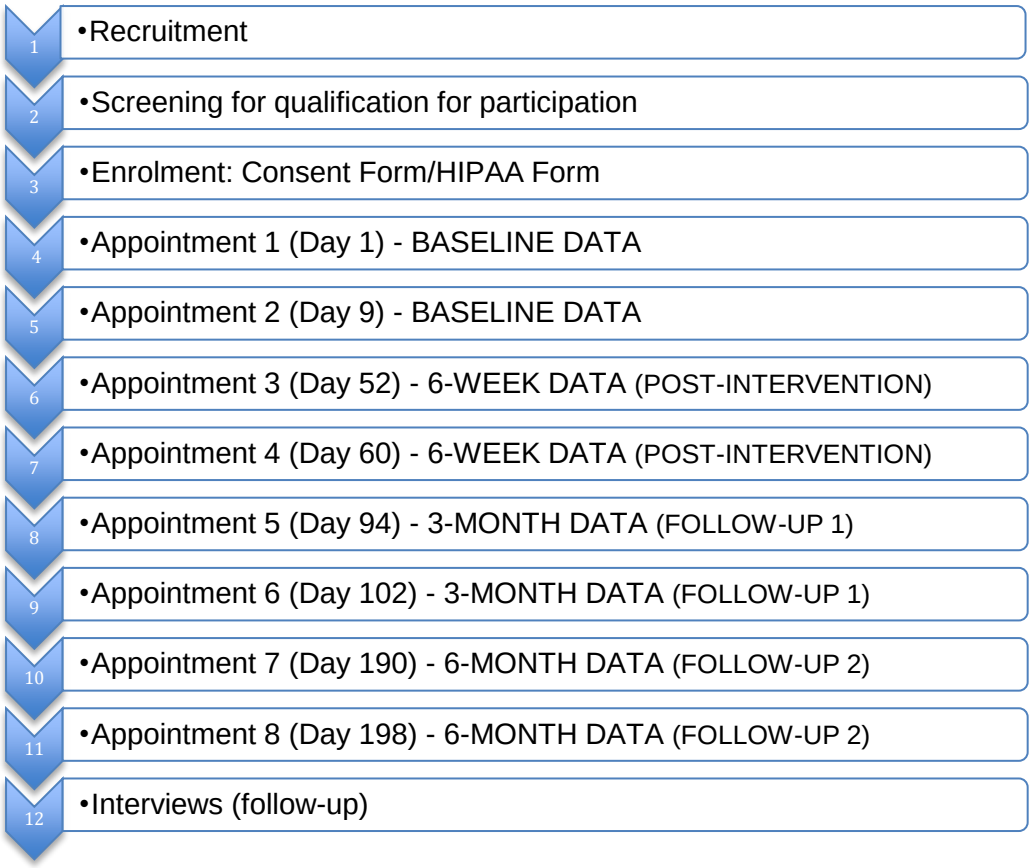


Figure 4.1: Summary of Implementation Phases

The approach of rolling enrolment required a specific outline of participant appointments in relation to a strict timeline (see Table 4.5). This was vital for the research assistants to ensure proper protocol. Despite several continuous obstacles and challenges, the implementation of *Study 2* was successfully completed, a success primarily attributed to a thoroughly planned, detailed research protocol, excellent research assistants and effective partnerships.

Table 4.5 presents the varying elements that the intervention group and the control group were exposed to, respectively. The key difference between the two groups was the intervention group's exposure to the selected intervention application (Fitocracy). Each intervention group participant was introduced to the application during the second appointment (Table 4.5). Research assistants conducted an orientation to Fitocracy for the research participant, getting them simultaneously set up with a personalised profile within the application. Research participants could ask questions for clarification and research assistants ensured that each participant successfully created a profile, and understood the basic functions of it. Further, research participants were then encouraged to utilise the intervention application via a personal computing device; however, it is important to note that they were not forced to do so, thus giving the research participant the choice whether to engage with the application over the next six months or not.

Control group participants were simply provided with an informational brochure about safely participating in physical activity. The same was given to intervention group participants. Both groups were asked to adhere to the same appointment schedule; however, the appointments varied slightly based on group allocation, as for example the aforementioned Fitocracy orientation. Another difference in

appointment structure was implemented during the third appointment, when intervention group participants were asked to complete the Player Experience of Need Satisfaction (PENS) questionnaire (see Chapter 5 for an evaluation study of user experience, for which PENS was utilised).

All other appointment structures were the same for both the intervention and the control group, entailing the data collection of biometric measurements, accelerometer check-out, data collection over a seven-day period and check-in. Further, all research participants were asked to complete the BREQ-2 and IMI questionnaire at baseline, six weeks, three months and six months, regardless of group allocation.

The detailed information outlined in Table 4.5 was available only to the research team to guide each step of the process coherently. For each appointment, a clear script was designed (see Appendix 4.23) and followed by each of the research assistants, which ensured exact replication of appointment procedures and interaction with research participants.

4.4 Data Analysis

4.4.1 Overview

To determine the effects of the intervention, we fitted a linear mixed model for each of the outcomes: MVPA, BMI, weight and body fat over six months. The analysis of a linear mixed model has been widely used in longitudinal data where repeated measurements of the same subjects are taken over the study period. This allows the assessment of within-subject changes in the outcome over time and the between-subject differences (i.e., treatment effect) at any time point. The mixed model included treatment (control or intervention), time (baseline, six-week, three-month and six-month data), and interaction terms between treatment and time as fixed-effects and subject as random-effects. To adjust for any baseline differences between the two groups, this model also included gender, age, baseline BMI and MVPA.

Assumptions of linear mixed models were verified by visual inspection of residual plots. Adjusted means and its 95% confidence intervals were reported by group at each time point. P-values of treatment simple effects were reported to compare group means at each time point.

A separate examination of the motivation for physical activity and physical activity levels was conducted. To investigate possible associations between these two items, a linear mixed model was utilised with MVPA as the outcome. Further, an assessment of whether participants' motivation changed over the course of the study was completed. For this, again, we used a linear mixed-model analysis, evaluating each subscale of the BREQ-2 and the IMI.

Table 4.5: Intervention Implementation Process

	Time points	Measurements/Other	Intervention Group (IG)	Control Group (CG)
BASELINE DATA	**Day 1** **APPOINTMENT #1**	1. Consent/HIPAA Form Check 2. Online questionnaire (onsite) 3. Lab-measured height, weight, BMI and body composition 4. Research assistant will configure accelerometer for 7-day period 5. Subject is provided next appointment reminder (in 7 days)	X	X
	Day 2 – Day 8 (7 full days)	Subject wears accelerometer	X	X
	Day 9 **APPOINTMENT #2**	1. Subject returns accelerometer 2. Subject gets signed up for Fitocracy (username and password provided by research staff) 3. Subject receives a Fitocracy orientation & is instructed to begin the next day 4. Subject receives Physical Activity Safety Information Sheet 5. Subject is provided with next appointment reminder	X	**1. X** **2. N/A** **3. N/A** **4. X** **5. X**
INTERVENTION	**Day 10 – 51** (42 days = 6 weeks)		X	**N/A**

Table 4.5: Intervention Implementation Process continued				
	Time points	**Measurements/Other**	**Intervention Group (IG)**	**Control Group (CG)**
FOLLOW-UP 1 (6 weeks)	**Day 52** **APPOINTMENT #3**	1. Online questionnaire (onsite) 2. PENS Questionnaire (paper) 3. Lab-measured height, weight, BMI and body composition 4. Research assistant will configure accelerometer for 7-day period 5. Subject is provided with next appointment reminder (in 7 days)	X	**1. X** **2. N/A** **3. X** **4. X** **5. X**
	Day 53 – 59 (7 full days)	Subject wears accelerometer	X	X
	Day 60 **APPOINTMENT #4**	1. Subject returns accelerometer 2. Subject is provided with next appointment reminder	X	X
FOLLOW-UP 2 (3 months)	**Day 94** **APPOINTMENT #5**	1. Online questionnaire (onsite) 2. Lab-measured height, weight, BMI and body composition 3. Research assistant will configure accelerometer for 7-day period 4. Subject is provided with next appointment reminder (in 7 days)	X	**1. X** **2. X** **3. X** **4. X**
	Day 95 – 101 (7 full days)	Subject wears accelerometer	X	X
	Day 102 **APPOINTMENT #6**	1. Subject returns accelerometer 2. Subject is provided with next appointment reminder		**1. X** **2. X**

Table 4.5: Intervention Implementation Process continued				
	Time points	**Measurements/Other**	**Intervention Group (IG)**	**Control Group (CG)**
FOLLOW-UP 3 (6 months)	**Day 190** **APPOINTMENT #7**	1. Online questionnaire (onsite) 2. Lab-measured height, weight, BMI and body composition 3. Research assistant will configure accelerometer for 7-day period 4. Subject is provided with next appointment reminder (in 7 days)	X	**1. X** **2. X** **3. X** **4. X**
	Day 191 – 197 (7 full days)	Subject wears accelerometer	X	X
	Day 198 **APPOINTMENT #8**	Subject returns accelerometer	X	X
	Day 199 - ?	Interviews (questions will differ for each group)	X	X

4.4.2 MVPA Results

MVPA data was collected via the GENEActiv accelerometer system at four different time points: baseline, after six weeks (post-intervention), after three months (follow-up 1) and after six months (follow-up 2). Each participant in the control and intervention group was asked to wear the accelerometer for a seven-day period at each of the time points. The GENEActiv accelerometer is worn on the wrist (left or right) chosen by the participant. Participants were blinded to the data the device collected and were simply given instructions to keep the accelerometer on at all times until returning to their next appointment.

Table 4.6 presents the results of the descriptive analysis on MVPA outlining mean accelerometer readings over six months by the control and intervention groups. Further, it breaks down the mean minutes by moderate and vigorous activity in minutes per day. The variations in sample size for each time point are due to the following factors: attrition rate and/or malfunctioning accelerometer devices. At baseline, we obtained data for 68 participants successfully. At six weeks, only 62 successful data sets were entered. At three months, 58 complete accelerometer data sets were measured and at six months, 56 total successful accelerometer data sets were taken.

Table 4.6: Mean Accelerometer Readings Over Time by Group

	CONTROL						**INTERVENTION**					
	Moderate Activity (min/day)			**Vigorous Activity** (min/day)			**Moderate Activity** (min/day)			**Vigorous Activity** (min/day)		
	N	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**
Baseline	26	150.3	58.2	26	2.6	3.4	42	129.7	45.5	42	2.4	3.2
Week 6	22	144.7	56.2	22	3.1	4.0	40	131.2	43.4	40	2.5	3.1
Month 3	23	149.3	69.5	23	4.0	4.9	35	134.8	41.1	35	2.3	2.4
Month 6	20	139.9	48.6	20	2.7	3.4	36	129.3	46.1	36	2.4	3.3

A linear mixed model for MVPA was fitted to determine the effects of this intervention. When adjusting (for age, gender, baseline BMI and its baseline value) mean MVPA measured in minutes per day by group over a period of six months, considering all four data collection points, no significant changes were detected (see Table 4.7 and Figure 4.2). However, at month three, the mean MVPA in the intervention group tended to be higher than in the control group. However, this difference was not statistically significant (p=0.189). Further, the mean values for MVPA in the control group clearly decreased over a period of six months with a short spike at three months, whereas the mean for MVPA for the intervention group increased steadily during the first three months; however, at six months, it then dropped off to a level lower than the baseline reading. None of these observations were statistically significant.

Table 4.7 and Figure 4.2 show the adjusted mean MVPA in minutes per day by group over all four data collection time points. The red graph illustrates MVPA among the intervention group and the blue graph demonstrates MVPA within the control group (see Figure 4.2)

Table 4.7: Adjusted Mean MVPA (Min/Day) by Group

	Time	Adjusted mean	95% confidence interval	
Control	Baseline	141.4	130.2	152.7
	Week 6	138.4	126.4	150.5
	Month 3	135.2	123.0	147.3
	Month 6	131.4	118.8	144.0
Intervention	Baseline	138.4	129.5	147.3
	Week 6	139.5	130.3	148.7
	Month 3	145.5	135.7	155.2
	Month 6	135.4	125.8	145.0

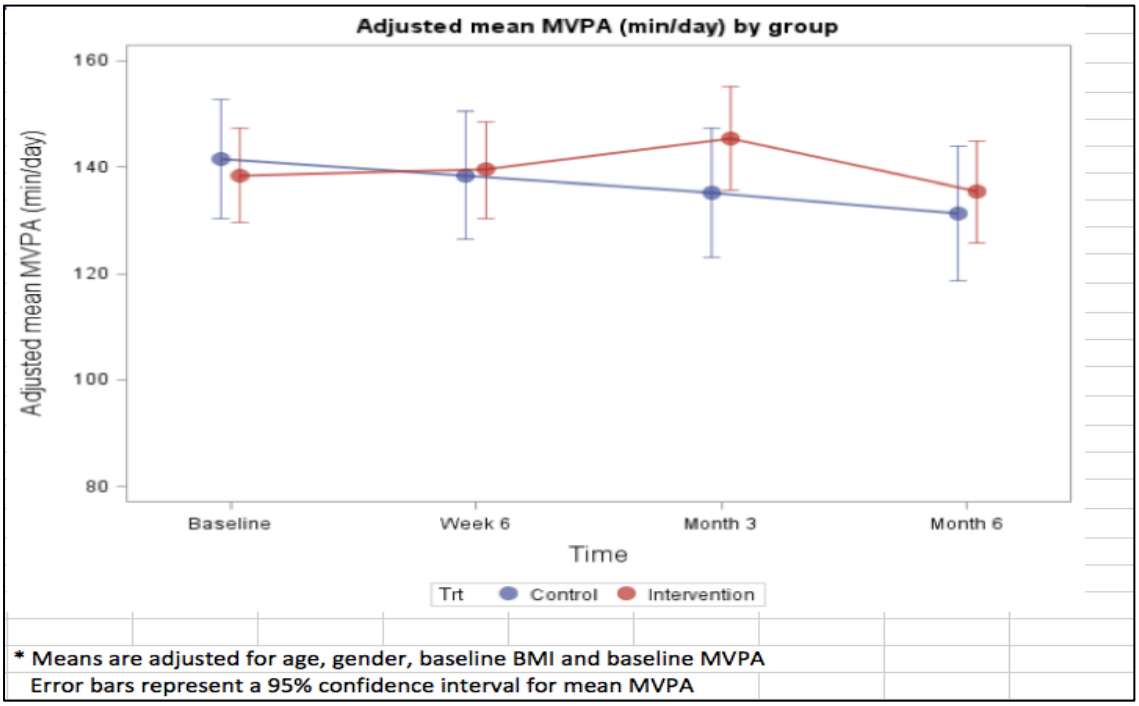


Figure 4.2: Adjusted Mean MVPA (Min/Day) by Group

4.4.3 Motivation for Physical Activity Questionnaires Results

The BREQ-2 has six subscales: 1) amotivation; 2) external regulation; 3) introjected regulation; 4) identified regulation; 5) intrinsic regulation; and 6) relative autonomy index (RAI). There are a total of 19 questions, which the respondent is asked to answer according to what extent each of the items are true for him or her. The answering system consists of a 5-point Likert scale (zero to five), with the number zero representing the answer of not being true and the number five being very true.

The IMI for this study included six subscales: 1) interest/enjoyment; 2) perceived competence; 3) effort/importance; 4) pressure/tension; 5) perceived choice; and 6) value/usefulness. The IMI consisted of 37 questions and employed an answering scheme based on a 7-point Likert scale, with one not being true at all and with seven being extremely true. The interest/enjoyment subscale is the main indicator for intrinsic motivation.

Both of the questionnaires were combined for the online version that participants were asked to complete throughout the study. At baseline, 69 participants took the online combined questionnaire, at six weeks and three months 67 participants participated and at six months 65 participants completed the online questionnaire. The difference in participation rate is attributed to the dropout rate. Descriptive results of mean values for each questionnaire and their subscales can be found in Table 4.8 and 4.9 respectively.

To assess whether motivation for exercise changed over time in this study, we used a linear mixed-model analysis. We fitted a mixed model, for each subscale of the BREQ-2 and the IMI questionnaires, including gender, age, treatment and time as fixed-effects and subjects as random-effects. For results, we adjusted the means and its 95% confidence intervals reported at each time point by group.

We found no significant changes in motivation over time and no significant differences between the control and intervention groups at any of the time points for all subscales of BREQ-2 except for identified regulation. At six weeks, the intervention group showed a significant increase in identified regulation values compared to the control group (see Table 4.10 and Figure 4.4). However, no significant differences were found at any other time points between the two groups in relation to the BREQ-2 questionnaire. The IMI subscales also showed no significant differences at any time point between the two groups. Further, no significant changes in any of the IMI subscales were detected.

Table 4.8: Mean Values BREQ-2 Subscales by Group

	CONTROL				INTERVENTION			
	Baseline	6 Weeks	3 Months	6 Months	Baseline	6 Weeks	3 Months	6 Months
Amotivation	1.00	0.88	1.03	0.76	0.70	0.76	0.70	0.77
External regulation	1.32	1.38	1.40	1.23	1.34	1.46	1.29	1.39
Introjected regulation	2.03	2.05	2.10	1.85	1.76	1.86	1.92	2.05
Identified regulation	2.41	2.37	2.59	2.52	2.47	2.68	2.70	2.83
Intrinsic regulation	1.93	1.90	2.24	2.20	1.99	2.21	2.22	2.15
Relative autonomy index	2.96	2.96	3.90	5.05	4.36	4.94	5.46	4.96

Table 4.9: Mean Values IMI Subscales by Group

	CONTROL				INTERVENTION			
	Baseline	6 Weeks	3 Months	6 Months	Baseline	6 Weeks	3 Months	6 Months
Interest/ Enjoyment	4.35	4.56	4.38	4.57	4.60	4.74	4.91	4.66
Perceived competence	4.06	4.17	4.26	4.31	3.77	4.08	4.26	4.30
Effort/ Importance	3.81	3.86	4.03	3.95	3.69	4.10	4.30	4.31
Pressure/ Tension	3.37	3.43	3.55	3.48	3.17	3.12	3.08	3.14
Perceived choice	5.04	4.96	5.13	4.96	5.17	4.99	5.15	5.20
Value	6.53	6.39	6.57	6.48	6.61	6.55	6.57	6.49

Table 4.10: Identified Regulation Values (BREQ-2)

	Time	Adjusted mean	95% confidence interval	
Control	Baseline	2.41	2.12	2.70
	Week 6	2.36	2.08	2.65
	Month 3	2.59	2.30	2.87
	Month 6	2.55	2.26	2.84
Intervention	Baseline	2.48	2.25	2.71
	Week 6	2.75	2.51	2.98
	Month 3	2.68	2.45	2.91
	Month 6	2.84	2.61	3.07

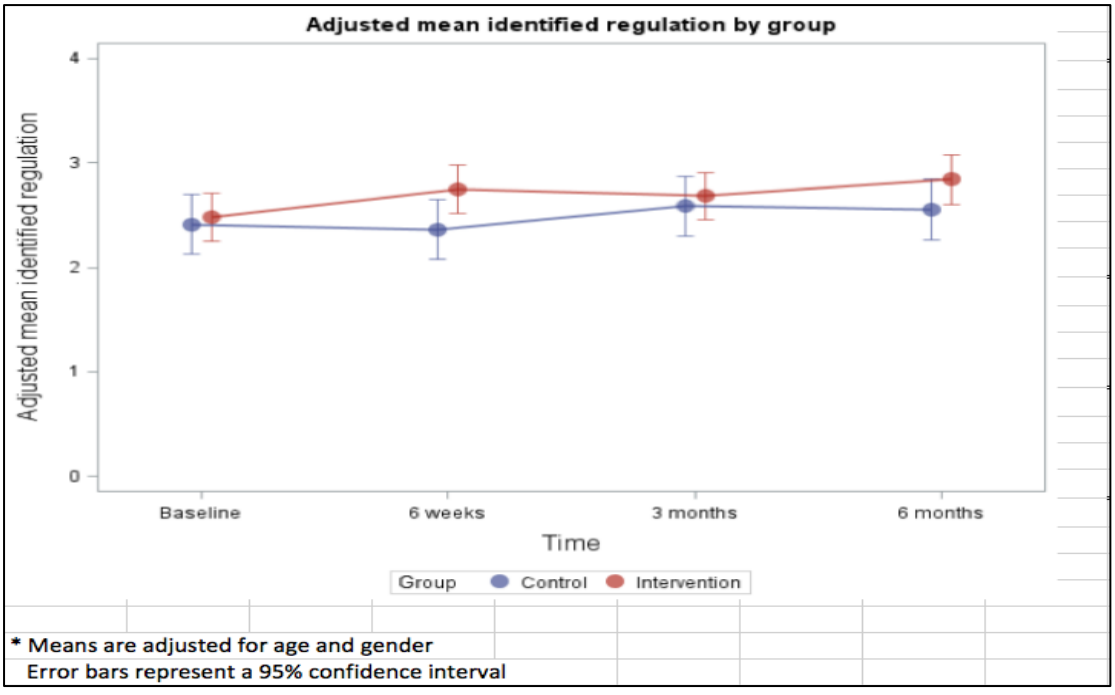


Figure 4.3: Identified Regulation Values (BREQ-2)

4.4.4 MVPA and Motivation for Physical Activity Association

To investigate general possible associations between motivation for physical activity and physical activity levels, we used linear mixed models with MVPA as the outcome. The difference of this mixed-model approach is that a subscale of BREQ-2 or IMI was included as opposed to the previous models referenced in association with MVPA and biometric data in this study. The mixed models utilised with MVPA examined treatment effect and its interaction with time. Here, we were interested in a beta coefficient for each of the motivation subscales adjusting for age, gender, baseline BMI, baseline MVPA and time. To report results, beta coefficients from the mixed model and standard error were included. P-values of the beta coefficients were also reported for the purpose of identifying which of the subscales were significantly associated with physical activity levels.

Table 4.11 shows beta coefficients for motivation subscales from mixed models on MVPA. Among the six subscales, external regulation and intrinsic regulation were found to have significant associations with physical activity levels. External regulation was found to be negatively associated with MVPA. A one-unit increment of external regulation was associated with a 6.76-minute reduction of MVPA per day (p=0.011), adjusting for age, gender, baseline BMI, baseline MVPA and time. Intrinsic regulation had a significantly positive association, indicating that a one-unit increment of this subscale was associated with a 4.52-minute increase of MVPA per day (p=0.031).

Among the six subscales of the IMI, only perceived competence had a significant association with physical activity levels. A one-unit increment was associated with a 5.13- minute increase of MVPA per day (p=0.004).

Table 4.11: MVPA and Motivation for Physical Activity Association

Dependent variable: MVPA (min/day)				
Exercise motivation*	**Slope**	**SE**	**P-value**	
BREQ-2 subscales				
Amotivation	1.44	2.44	0.56	
External regulation	-6.76	2.62	0.011	*
Introjected regulation	-3.29	2.25	0.15	
Identified regulation	0.97	2.72	0.72	
Intrinsic regulation	4.52	2.07	0.031	*
RAI	0.58	0.34	0.08	
IMI subscales				
Interest/Enjoyment	2.81	1.68	0.10	
Perceived competence	5.13	1.77	0.004	**
Effort/Importance	2.43	1.84	0.19	
Pressure/Tension	-3.19	1.62	0.05	
Perceived choice	3.40	2.46	0.17	
Value/Usefulness	-0.47	3.36	0.89	
* All variables are adjusted for: age, gender, baseline BMI, baseline MVPA, and time				

4.4.5 Biometrics Results

A repeated measure analysis of BMI, weight and body fat was conducted; however, this set of data was rather exploratory and does not directly correspond to the primary outcomes of this study. To examine whether or not the intervention had any effects on BMI, weight or body fat over a six-month period, we fitted a linear mixed model for each variable. Further, it included the treatment group (control and intervention), time (baseline, six weeks, three months and six months), and interaction terms between treatment and time as fixed-effects, as well as subjects as random-effects.

For BMI, there were no significant differences between the groups at any time point overall (see Table 4.12). However, when the analysis was stratified by the baseline MVPA, the intervention group had a mean BMI significantly lower than the control group at six months among those who had lower MVPA at the baseline.

Table 4.12: Mean BMI Over Time by Group

BMI (kg/m^2)	CONTROL			INTERVENTION		
	N	**Mean**	**SD**	**N**	**Mean**	**SD**
Baseline	26	28.3	6.8	43	25.5	5.1
6 Weeks	26	28.3	6.9	43	25.5	5.0
3 Months	26	28.4	7.1	41	25.4	4.9
6 Months	24	29.1	7.3	40	25.3	5.1

Similar results were found for weight. There were no significant differences between the groups at any time point overall (see Table 4.13). Among those who had lower MVPA at baseline, the mean weight was significantly lower in the intervention group than the control at three and six months ($p = 0.032$ and 0.006, respectively).

Table 4.13: Mean Weight Over Time by Group

Weight (kg)	CONTROL			INTERVENTION		
	N	**Mean**	**SD**	**N**	**Mean**	**SD**
Baseline	26	80.2	21.8	43	71.1	18.3
6 Weeks	26	80.3	22.3	43	71.2	18.4
3 Months	26	80.8	22.7	41	71.0	18.3
6 Months	24	82.6	23.5	40	70.7	18.8

There were no significant differences between the groups for body fat percentage overall (see Table 4.14). Even after stratification by the baseline MVPA, no significant differences regarding body fat percentage were detected.

Table 4.14: Mean Body Fat Over Time by Group

Body fat (%)	CONTROL			INTERVENTION		
	N	Mean	SD	N	Mean	SD
Baseline	26	34.3	10.4	42	32.7	8.2
6 Weeks	25	33.0	9.9	40	32.0	8.7
3 Months	26	34.2	10.7	40	31.3	8.2
6 Months	24	34.6	11.2	39	31.1	8.2

4.4.6 Revised Sample Size Calculations

For a possible full future trial, the sample size was re-calculated based on the results of moderate physical activity (MPA) per day in *Study 2*. Data from the baseline and the three-months data collection were used for calculation. At three months, the control group showed on average a one-minute decrease in MPA, while the intervention group increased MPA by five minutes. Thus, we used the effect size of a six-minute difference between the two groups. Based on correlations between the baseline and three-month measurements (0.84 and 0.63 for control and intervention, respectively), the standard deviation of the difference in the two time points was approximately 38 minutes per day for both groups. Assuming the power of 80%, the type I error rate of 0.05, and the allocation ratio of two to one (control to intervention), these resulted in a required sample size of 1,419 subjects in total (946 and 473 subjects). When the observed attrition rate of 16% was taken into account, the required sample size is 1,689 subjects (1126 and 563 subjects).

4.5 Discussion

4.5.1 Findings

Study 2 represents a rigorous research protocol, built on evidence-based methodology and theoretical frameworks, unlike many existing research studies as presented in Chapter 2. Further, the research protocol for *Study 2* included not only a short-term intervention, but also three- and six-month follow-up data collection in order to obtain a better understanding of physical activity behaviour over a longer term. Three hypotheses were carefully articulated for *Study 2* (see Section 4.1.3).

Hypothesis one asserted that sedentary adults will increase their physical activity levels measured at six weeks, three months and six months as a result of a gamefully designed physical activity intervention. The results of *Study 2* show, contrary to the primary hypothesis, no significant changes in physical activity levels for the intervention group at any of the time points within the study. An increase in physical activity for the intervention group compared to the control group was observed at three months (10.3 minutes per day); however, this was not significant based on the sample size. This null hypothesis result is an important finding, adding to the limited current available knowledge gained from previous research, which indicates varying results and trends thus far.

For example, Gotsis et al. (2013) observed an increase in exercise frequency in a field experiment over 13 weeks; however, that study relied on participants' self-reported exercise data only; thus, results lack objectivity and were furthermore applicable only for the time frame of 13 weeks. Thorsteinsen, Vittersø and

Svendsen (2014) detected a significant increase in physical activity levels among the test group during a randomised controlled trial over three months, however at week five and nine only. Again, this relied on participants' self-reported activity, which does not provide objective data leading to clear conclusions. Zuckerman and Gal-Oz (2014) conducted a modified RCT over two short time frames (two weeks and ten days) and observed increased walking time (statistically significant) in the various groups (quantified and gamified versions), concluding that the gamified intervention version was not more effective than alternative strategies. This study employed mobile-based step- tracking features, and thus collected more objective data than the previously mentioned studies. An observed increase in walking time over a short period of time does not contribute to the understanding of whether gameful design contributes to actual physical activity behaviour change long term.

This study offers, via rigorous research methodology, further understanding differing from the aforementioned studies. *Study 2* included the use of objective physical activity measurement via accelerometers specifically designed for research, providing a more reliable method of physical activity data collection. The observed results indicate no significant physical activity changes in the intervention group at any time, leading to a conclusion that the intervention application, Fitocracy, did not have an impact on physical activity levels as asserted in the hypothesis. Although current research literature suggests that gameful design may hold the key to increasing motivation and therefore increasing physical activity levels sustained over time (Recio, 2012), the results of this study do not support such claims. Due to lack of rigorous research investigating the effectiveness of gameful design motivating physical activity behaviour (Kato, 2012), previous reports that this is indeed the case may not actually be reliable. *Study 2*, to our knowledge, is one of the first of its kind to respond to the previously identified gaps in the investigation of the efficacy of gameful design on physical activity behaviour and, thus, it adds valuable knowledge to current understanding.

Study 3 (Chapter 5) of this PhD research thesis will provide further insight into the potential reasons as to why no increase in physical activity levels was observed in *Study 2*. An investigation of user engagement and experience (*Study 3*) among the intervention group will add vital and valuable knowledge related to the processes of how and why physical activity behaviour remained unchanged.

The second hypothesis for this study asserted that sedentary adults exposed to a six-week, web-based, gamefully designed physical activity intervention will have increased internalised motivation for physical activity measured at six weeks, three months and six months. The first data analysis, aiming to answer the secondary hypothesis, resulted in finding no significant differences between the control and intervention group at any of the four time points for all subscales except for identified regulation (BREQ-2). The intervention group showed a significant increase in identified regulation values compared with the control group at six weeks, which occurred immediately after the six-week exposure to Fitocracy. Identified regulation is considered to be an autonomous internalised form of motivation, referring to the motivation related to one's conscious value for something (Ryan & Deci, 2000). This can mean, for example, that physical activity, in this case, was perceived as beneficial to achieving a particular goal; however, physical activity may not be enjoyable to the participants in itself. A potential explanation for increased identified regulation at six weeks among the intervention group may be that the intervention application,

Fitocracy, added value to participating in physical activity. However, the findings of this particular parameter are difficult to interpret without qualitative, more granular analysis, which again validates the necessity for *Study 3* (evaluation of user engagement and experience).

Study 2 data indicates a partial fulfilment of results for hypothesis two, namely that internalised motivation for physical activity was increased at six weeks, immediately following the intervention, among the intervention group, but not at three months or six months. Sailer et al. (2013) note that the audience, the environment and the context of gameful design can greatly impact the effectiveness of the results. The observed change in internalised motivation for physical activity at six weeks in this study could potentially be the result of any or all of those three aspects. To determine whether the gamefully designed physical activity application had a direct impact on the increased identified regulation among the intervention group requires a deeper investigation via qualitative data collection (e.g. interviews) as presented in Chapter 5. Further, this result contributes to other important questions, such as whether theoretical frameworks are needed in order to develop a clearer understanding of the progression of motivation and what steps might be crucial to move a person from amotivation and no action to external motivation and action and ultimately to intrinsic motivation and sustained behaviour, particularly in relation to gamefully designed physical activity applications. It may also be valuable to consider whether intrinsic motivation is actually necessary to observe adherence to physical activity behaviour over the long term, or if increased internalised motivational levels are sufficient. This concept may yield a deeper exploration of motivational theory specifically in connection to physical activity behaviour in today's societal context and in connection with web- and/or mobile-based physical activity applications.

What is clear, however, based on the results presented in this study, is that there was no observation of increased physical activity levels, no increase in absolute intrinsic motivational levels, and limited increased internalised motivation for physical activity. Based on SDT (Deci & Ryan, 2000), these findings are in line with previous studies indicating that behaviour is correlated with greater internalising of motivation for that particular behaviour, in this case physical activity. In this study, we observed a significant change of identified regulation, which indicates a change in value and movement toward intrinsic motivation as presented on the Self-Determination Continuum (Deci & Ryan, 2000); however, we did not observe actual increased levels of intrinsic motivation for physical activity as a result of the intervention.

Hypothesis three asserted that increased internalised motivation for physical activity will mediate the effect of a gamefully designed physical activity intervention on the maintenance of increased physical activity at six weeks, three months and six months post-intervention. As highlighted in this section, increased MPVA was not observed at any time during the study. Thus, the tertiary hypothesis yields a null hypothesis in this study. All results obtained from the data analysis for *Study 2* indicate that the gamefully designed physical activity intervention had no impact on physical activity levels. However, as noted earlier, *Study 3* will add additional insights into potential explanations for these results and also determine the feasibility and acceptability of the intervention protocol in *Study 2*. It is possible that due to the small sample size, significant results could not be detected. Further, it is also important to consider that multiple factors could

be the contributors to the results observed, meaning that a preliminary conclusion—that the gamefully designed physical activity intervention was ineffective—might hide a much more complex picture, which future studies with an adequate sample size need to explore.

Further findings of the data analysis presented in the previous section correspond to objectives three and four of *Study 2*. Objective three set out to estimate the variance in the primary outcome to inform sample size calculations for a definitive randomised controlled trial (see Section 4.4.7). Based on the data collected in *Study 2*, the revised sample size calculations asserted that a required sample size of 1689 subjects (1126 intervention group subjects and 563 control group subjects) was needed. This number includes the observed attrition rate of 16%. *Study 2* hereby provided valuable data, informing the more accurate calculations of a sample size for future trials, which has previously been difficult due to the lack of randomised controlled trials available.

Objective four of *Study 2* aimed to evaluate the effects of increased intrinsic motivation on levels of physical activity. Thus, further data analysis of *Study 2* explored the associations of MVPA with all the subscales of each instrument (BREQ-2 and IMI). Among the six subscales of the BREQ-2, external regulation and intrinsic regulation had significant associations with MVPA. External regulation had a negative association and intrinsic regulation had a positive association with MVPA. A one-unit increment in intrinsic regulation was associated with a 4.52-minute of MVPA per-day increase. Further, perceived competence, a subscale of the IMI instrument, showed a 5.13-minute of MVPA per day increase in association with a one-unit increment. These findings confirm previous research positively associating SDT principles with increased physical activity behaviour (Teixeira et al., 2012). The research participants in *Study 2*, regardless of group allocation, who had higher values related to intrinsic regulation, demonstrated higher levels of physical activity behaviour. This finding, although not novel, is valuable, as it validates existing theories, such as SDT (Deci & Ryan, 2000). The same is true for the finding related to external regulation and decreased levels of physical activity. Competence is one of the three basic psychological needs and can be positively correlated with self-determined behaviour (Deci & Ryan, 2000), as it shows to be true in *Study 2*, where it was specifically assessed in relation to physical activity behaviour. It is vital to note here that these findings do not relate to the gamefully designed physical activity application implemented in *Study 2*. This analysis is merely looking at the general correlations between motivation and physical activity behaviour, irrespective of group allocation and intervention exposure.

4.5.2 Limitations

This study was carried out with a sample size smaller than the estimated calculations for a full trial. To observe statistically significant changes and differences, a larger sample is required (see Section 4.4.7). However, considering this was a pilot randomised controlled trial the number of participants was deemed to be appropriate.

The enrolment criteria in relation to physical activity levels were based on a self-report, seven-day recall questionnaire. Although the utilised tool is a validated measure, self-report physical activity measures can result in an overestimation of activity levels (Sallis & Saelens, 2000). Firmer conclusions regarding participants' actual regular activity levels could have been determined if objective measures were possible prior to enrolment in the study. The baseline data collection served that purpose; however, individuals already consciously knew they had enrolled in

a research study, which typically impacts their behaviours. Thus, it is inconclusive if all participants in this study were truly sedentary prior to enrolment in this study.

Enrolment criteria did not specify that participants had to be ready to become physically active and this was not part of the assessment upon successful enrolment either. Thus, it is unclear how ready participants were to make changes related to physical activity behaviour, which may have significantly influenced the outcomes of this study. Further, it was unknown if participants enrolling in this study had engaged with gamefully designed physical activity applications before or if they were even interested in doing so. This could have potentially impacted user engagement with the intervention application significantly.

The GENEActiv accelerometers purchased for this study came from a flawed manufactured line (related to the outer soft plastic shell), resulting in the necessity to replace every single device throughout the study period, which presented various challenges for sticking to the study protocol related to scheduling and the availability of devices. Fortunately, this issue was detected early on, allowing all research assistants to troubleshoot and make sure every participant had a well-functioning accelerometer. Many of the devices actually continued to work well even with an outer shell crack; however, if participants chose to go swimming, water would get into the inner part of the device and permanently ruin it. It is possible that isolated occasions contributed to inaccurate data collection or lack thereof in relation to the MVPA data due to this malfunction.

The process of downloading the data from the accelerometer devices was a highly complicated process, requiring lengthy training periods and attention to detail. The GENEActiv system is not user-friendly or quick to download, thus presenting in itself a limitation to this study. Every single accelerometer device takes an average of 30 minutes to download. Considering that there were 68 active participants and each participant had to wear the accelerometer at four different time points, 272 sets of accelerometer data had to be downloaded, which resulted in 136 hours for just this particular task, which was minute in comparison to all other aspects of managing the trial. Each device then had to be cleaned, disinfected and recharged, which often took up to five hours per device.

All online questionnaires given to participants produced self-reported data. The same questionnaires, assessing motivation for physical activity, were administered at all four time points and both of the questionnaires were very similar. The participant interviews revealed (see Chapter 5) that the exhaustive repetition of questions of the two questionnaires at four different time points was confusing and annoying; thus, participants often did not answer with the same care each time. This may have affected the data collected from these questionnaires.

The study centre was centrally located; however, the recruitment territory was large based on the need to recruit a large number of participants. Having only one study centre presented challenges in relation to adherence to research appointments. Participants who lived or worked substantial distances from the study centre often had to reschedule due to traffic, which is notorious in Southern California. Although there is not substantial evidence of a particular phenomenon related to Southern California culture, the majority of the research participants demonstrated very low levels of follow-through related to research appointment commitments. From the outset, the length of the research study (six months) seemed to be a key factor as to why many did not consider enrolling in the study, even if they qualified. Further, the lack of dependability in relation to research

appointments resulted in employing daily protocols of text message reminders. Fortunately, the trend of no-shows was immediately addressed so that data was not comprised. That often meant that additional research appointments had to be added to the schedule to accommodate rescheduled appointments. This presented a significant challenge organisationally; however, it was ensured that this did not become a true limitation to the study.

As is commonplace with quantitative studies, the emphasis of the aims and outcomes are placed on generalisable overall indications, trends and results. However, it is possible that the phenomenon being investigated is more complex and needs investigation at the more granular level, which is accomplished with qualitative data collection. The limitation truly lies in looking at the results of *Study 2* in an isolated fashion. However, this overall research consists of another study *(Study 3),* which will precisely accomplish the aforementioned: namely, evaluate user engagement, user experience and processes of *Study 1 and Study 2*, providing deeper insights into possible impacts.

4.5.3 Future Research Directions

Even though the quantitative results of *Study 2* confirmed the null hypothesis in relation to all three hypotheses articulated for the research study, future studies should continue to develop theory-driven, rigorous research protocols in relation to gameful design, motivation for physical activity and MVPA. One study with a null hypothesis result amidst very few other research studies, all yielding various conclusions, is not sufficient. In order to observe significant findings, a larger randomised controlled trial should be conducted as calculated for the re-estimation of sample size (Section 4.4.7).

MVPA should always be assessed by well-functioning accelerometers designed for research trials in order to provide accurate physical activity data. A thorough evaluation of available devices should be undertaken before choosing a suitable one for the purpose of a large trial. As indicated in the review of literature in Chapter 2 of this thesis, future research should continue to employ research time frames over a longer period of time to observe changes in physical activity beyond the initial novelty effect, which may occur in short-term interventions. *Study 2* demonstrated a rigorous protocol employing longer-term follow-up periods, adding valuable observations.

Future studies should focus on assessing people who are already voluntarily engaging with gamefully designed physical activity applications, in order to observe changes in motivation and physical activity. The advantage of focusing on individuals who have already decided to engage with an application is that the autonomous choice to engage with a tool has already been made, unlike in this study. Adoption of regular engagement with a gamefully designed application may in itself present a barrier, which can prevent the evaluation of the impact of the application. In other words, if a research participant never engages with an intervention application, the impact of the intervention application cannot be assessed. It is possible that this may also be tied to readiness to change (in relation to physical activity behaviour in this study), which should also be considered for inclusion in future research. It may be necessary to employ different strategies of gameful design for individuals who are ready to change and those who are not. This again presents an opportunity for further research.

Lastly, it is recommended that any future research should employ quantitative and qualitative methods in order to obtain a more complete understanding of the phenomenon under investigation. However, the

quantitative results in this study do not answer questions related to the how and why, which are essential when investigating human motivation and behaviour, as these cannot be isolated in a particular context. Many different factors can impact motivation for physical activity behaviour and thus actual physical activity levels and it is important to continue to gain a deeper understanding of the various processes involved to search for solutions to positively impact physical activity behaviours in sedentary adults.

4.5.4 Conclusions

Study 2 primarily aimed to assess the effectiveness of a web- and mobile-based gamefully designed physical activity intervention on physical activity levels of sedentary adults. Secondly, *Study 2* aimed to establish a link between gameful applications and internalised motivation for physical activity.

The quantitative results of *Study 2* showed that there were no statistically significant changes observed in relation to MVPA and intrinsic motivation among the overall sample of the intervention group exposed to a gamefully designed physical activity intervention. For a future full randomised controlled trial, a much larger sample size is necessary (see Section 4.4.7) to allow significant differences to be detected.

Study 2 provided further validation that there is a positive correlation between intrinsic regulation and MVPA and that there is a negative association between external regulation and MVPA. These observations validate constructs of SDT (Deci & Ryan, 2000). Introjected regulation, however, yielded significant results among the intervention group, indicating that internalised motivation for physical activity was experienced at the six-week data collection point. It is unclear, based on the quantitative data, why that was the case and whether this can be attributed to the intervention application (Fitocracy).

Findings of *Study 2* clearly merit further evaluation of more complex processes, which are not evident via quantitative data collection. Following from this analysis of quantitative data in relation to biometrics, MVPA and motivation for physical activity, the next study (*Study 3*) aims to further investigate the processes and experiences that contributed to the observed results in *Study 2*. The qualitative data of *Study 3* was primarily obtained via one-on-one interviews with participants from both the intervention and control groups, although the main focus was on interviewing a sample of the intervention group to provide detailed insight into the granular components affecting the outcome of *Study 2*.

CHAPTER 5: STUDY 3 – PROCESS EVALUATION

5.1 Introduction

The *Theoretical Framework Design Study* (*Study 1*) produced a novel theory-based framework, which resulted in the *Taxonomy of SMAs for Gameful Design*. This was used in the selection of a web- and mobile-based gamefully designed physical activity application called Fitocracy (*Intervention Implementation Example Case Study* or *Study 2*). Together, they present a new design approach connecting concepts related to gameful design, motivation and physical activity. *Study 3* presents a comprehensive process evaluation of these elements answering to research question 3: *How does a gamefully designed physical activity intervention selected and implemented with this process impact the motivation for physical activity, engagement with the intervention application and physical activity levels among sedentary adults?*

Specifically, the goal of this chapter is to evaluate the strengths and weaknesses of the approach to support future users by: (1) estimating recruitment and participation rates in the intervention group and the control group and understanding underlying causal factors; (2) assessing adoption, usage and retention rates of the gamefully designed application and its SMAs; (3) assessing how useful and practical the *Taxonomy of SMAs for Gameful Design* was in selecting an intervention; (4) evaluating the mechanisms of impact on motivation for physical activity and physical activity behaviour for participants in the intervention group, including assessing whether and how the SMAs identified in the chosen intervention affected desired psychological and behavioural outcomes; (5) assessing the effectiveness of the delivery mechanisms of the intervention conducted; (6) evaluating the influence of external factors on the delivery and functioning of the intervention and (7) estimating the resource use and costs associated with the intervention implementation and assessing their feasibility relative to large-scale implementations.

5.2 Process Evaluation

5.2.1 Introduction

Process evaluations have been recognised to contribute to the assessment of randomised controlled trials in that they can help with the assessment of the quality of implementation, evaluate fidelity and, very importantly, identify causal mechanisms and contextual factors of the observed outcomes (Craig et al., 2008). In addition, process evaluations provide important information for future replication of similar interventions, which effect sizes simply do not do (Moore et al., 2015). This research study showcases the novel development of a theory-informed methodology and newly proposed taxonomy, which led to the selection of an intervention application for the usage in an example case intervention study; thus, it is vital to conduct a process evaluation to identify issues related to context, mechanisms of impact, replication and further recommendations for validation and modification. Specifically, it is necessary to assess whether the selected gamefully designed application influenced the motivational and behavioural mediators.

5.2.2 Methods

Assessment of the aforementioned objectives (Section 5.1) occurred via a variety of measurements and data collections. Measurements were taken at different

time points throughout the course of the study to capture contextual factors and changes. A mixed-methods quantitative and qualitative data collection protocol was implemented for a comprehensive evaluation of the different aspects of this three-phase research approach.

A detailed account of recruitment and participation rates was kept, depicting important information about enrolment, retention and attrition rates (Section 5.2.3.1). Data from each participant's personal web profile on the intervention application was collected: namely, number of activity days tracked; number of workouts tracked; number of groups joined; number of people following; number of followers, points, badges and levels achieved. This data was extracted from the participant profiles at six weeks and six months (Section 5.2.3.2).

The PENS questionnaire was used to assess user engagement with Fitocracy (Section 5.2.3.3). The questionnaire was adapted to this particular study by specifically referring to Fitocracy as the application being assessed. PENS is an applied model designed to understand the experience of a player in a game context, looking particularly at key components related to SDT constructs (Rigby & Ryan, 2007).

Individual semi-structured interviews were conducted (Section 5.2.3.4) to elicit feedback regarding the experience and quality of the example case pilot intervention, mechanisms of impact and change, influence of external factors, quality of delivery of mechanisms, study design and administration. Interviews were held after the second follow-up data collection (at six months) with intervention group participants. Lastly, the resource use and costs associated with the example case pilot intervention were estimated (Section 5.2.3.5).

5.2.3 Results

5.2.3.1 Recruitment and Participation Rates

Recruitment lasted for eight months and 21 days between September 2014 and May 2015 and occurred in the IE of Southern California primarily at LLU, La Sierra University and local churches. The IE is a metropolitan area covering more than 70,000 km^2 with 18 million people counted during the 2010 United States Census (Wikipedia, 2016). Additional recruitment venues included social media (specifically Facebook) and advertisements in local newspapers and magazines (print and digital). Further, a local radio station (KSGN) included advertisements on air and online.

LLU had 4,729 enrolled students in the fall of 2014 (beginning of the 2014/2015 school year) and 1,624 full-time faculty (Loma Linda University, 2016). La Sierra University had a total student population of 2,440 in the 2013/2014 school year (which is the last official data set available) and has had on average 2,500 students enrolled (La Sierra University, 2016). The exact number of full-time faculty and staff was not available, but ranges between 200 and 300 people.

Table 5.1 presents an overview of the numbers of the recruitment territory and recruitment rates for each area. The total estimated recruitment percentage is 0.0062% with 119 individuals completing the online screening questionnaire (SurveyMonkey). Out of these, 83 people successfully enrolled in the study (*Study 2*). Of the 39 individuals who did not enrol, 19 did not qualify and 17 chose not to enrol. Two did not fully complete the screening and never returned messages for clarification. At the end of the study, 68 active participants remained with nine

dropping out for various reasons (all at very early stages) and six enrolling with a BMI above 40 (=exclusion criteria), who had to be asked to drop out of the study. However, because this was an error by the research team, these six were not counted as dropouts for participation rates. This resulted in an 11.7% attrition rate for the entire study.

Table 5.1: Recruitment Population Pool

	LLU	La Sierra University	Churches	Facebook	Other	Total
Population Pool	6,353	≈ 2,700	≈ 10,000	?	?	≈ 19,053
Recruitment #	38	23	14	15	31	119
Recruitment %	0.0060	0.0085	0.0014	?	?	0.0062

Table 5.2 shows recruitment populations based on the initial screening questionnaire, including answers to inclusion/exclusion criteria. It does not include information from open-ended questions. Notably, more than two-thirds of the population taking the online screening questionnaire were women.

Of the 68 active participants, not all participated successfully in every measure and every time point (baseline, six weeks, three months and six months). Reasons varied from illness to forgetting the appointment to car trouble and other personal reasons. However, participation rates for MVPA data also varied due to malfunctioning accelerometer devices as described in the previous chapter. Table 5.3 shows the various participation rates for each particular measure and time point.

Table 5.2: Recruitment Population Summary

Description	Value
Male	30.89% (n = 38)
Female	69.11% (n = 85)
Average height	66 inches (1.67 metres)
Ability to walk across room with two legs	100%
Ability to read and write in English	100%
Ability to access the Internet	99.19%
Ability to commit to six-month study	98.37%
Ability to come to study centre at LLU	95.12%
Ever had a heart condition	2.46%
Chest pain during physical activity	2.44%
Chest pain NOT during physical activity	4.07%
Loss of balance (dizziness, etc.)	3.25%
Bone or joint problem	5.69%
BP or heart condition drugs	4.07%
Any reason why you do not do physical activity	2.44%
How much time do you sit per day	Range: 0 hours to all day
Activity levels	Range: very low to high

The highest participation drop, a 17.65% attrition rate, was observed in the MVPA domain. This is not necessarily a participation drop per se as the accelerometer devices utilised malfunctioned on numerous occasions and some participants simply missed one of the appointments. Although the research team was quick to

respond to such situations, they were not able to remedy every single case; thus, this may have affected participation rates.

Table 5.3: Participation Rates Throughout Study 2

	MVPA (N)	Online Questionnaires (N)	BMI (N)	Weight (N)	Body Fat (N)
Baseline	100% (68)	100% (68)	100% (68)	100% (68)	100% (68)
Week 6	88.2% (60)	98.5% (67)	100% (68)	100% (68)	95.58% (65)
Month 3	85.2% (58)	98.5% (67)	98.5% (67)	98.5% (67)	97.05% (66)
Month 6	82.35% (56)	95.58% (65)	94.11% (64)	94.11% (64)	92.64% (63)
Attrition	17.65%	4.42%	5.89%	5.89%	7.36%

5.2.3.2 Adoption, Usage and Retention Rates

To assess adoption, usage and retention of the chosen intervention, Fitocracy, we collected the following data at two different time points (six weeks and six months): activity days tracked; workouts tracked; groups joined; people following; followers; points, badges and levels achieved. Since only intervention group participants (N = 41) had access to Fitocracy, data is limited to this group. Table 5.4 provides an overview of the different data points at the two different time points.

During the six-week intervention period, eight research participants chose not to engage at all with the application. This decreased to five at the second data collection point (six months). Out of the total intervention group sample (n = 41), 14 chose to engage with the application only one time during the six-week intervention, which decreased by one at the second measurement point. More than one login with Fitocracy was recorded from 19 participants at the six-week data collection point and 23 at the six-month data check.

Table 5.4: Fitocracy Adoption, Usage and Retention Overview

	Week 6	Month 6
No usage	N = 8	N = 5
One log-in only	N = 14	N = 13
More than one log-in	N = 19	N = 23
Highest log-in frequency	10	74
Average # of days of activity tracked	3.24	10.65
Average # of workouts tracked	3.48	11.39
Average # of groups joined	6.75	6.95
Average # of people following	5.29	5.34
Average # of followers	2.46	3.9
Average # of points earned	1,340	3,339.9
Average # of badges earned	1.34	1.95
Average # of levels achieved	3.02	4.04

The average number of workouts tracked differed slightly from the average number of days of activity tracked, since some engaged in multiple different workouts per day. The average of 3.24 days of activity tracked during the first six weeks indicates very low usage, translating into only about one login every two weeks. The highest login rate was 10 times during the first six weeks (tracked for four participants), which translates into 1.66 times per week. Considering that the

physical activity guidelines recommend a minimum of five days of physical activity per week (ACSM, 2014), this number is still low.

When participants completed the initial registration with Fitocracy, it automatically enrolled the participant into groups associated with their interests as entered during the sign-up process. Thus, participants did not originally actively choose group enrolment; however, they could modify it once their initial profile was set up. Fitocracy automatically assigns some system administrators to follow each new Fitocrat. No great differences in groups occurred between week six and month six, indicating that engagement with these items was low and likely left at the set-up default.

Table 5.5 presents adoption, usage and retention rates of Fitocracy for each participant comparing six weeks (6 w) and six months (6 m). Bolded numbers indicate that a change occurred; the colour grey is utilised for ease of view. This table more clearly illustrates the individual engagement with Fitocracy, which showcases the vast difference from participant to participant. One particular pattern that is noticeable is that if participants did not engage initially with the application, they were unlikely to engage with it after the initial six-week period. Tables 5.6 a and b illustrate a closer analysis of days of activity logged between baseline, six weeks and six months to showcase adoption, usage and retention of the main Fitocracy function (i.e. tracking physical activity) over the entire period of the research study. From the entire sample (n = 41) of the intervention group, 12.19% did not adopt (= open) the application at all; 7.3% adopted it after the initial six-week intervention. 48.78% nominally adopted and used Fitocracy during the six-week intervention. However, a total of 29.26% actually logged in only once and then not again during the six weeks, thus not representing actual usage.

This leaves a total of 19.5% who actually adopted and used the application during the first six weeks, but not again thereafter. Initial adoption, usage and retention rates throughout the six-month period were at 31.7% (n=13). However, significant usage was observed only in 9.7% (n=4) of the entire sample over a six-month period. The PENS questionnaire results and the interviews conducted with research participants post the six-month data collection point added qualitative data (see Section 5.2.3.4) providing valuable insight and possible explanations as to why adoption rates are rather low. One key element in this intervention was that participants had the choice to engage with the application and if they chose to do so, it was completely on their own and not in a controlled setting as is common with traditional physical activity interventions.

5.2.3.3 Player Experience of Need Satisfaction (PENS)

To obtain a better understanding of how participants experienced the intervention and to explore possible explanations for the low engagement rates, the PENS questionnaire was utilised. This questionnaire allows the exploration of the main claim that gameful applications support activity through intrinsic motivation and provides a deeper insight into the effectiveness of the application utilised in the intervention.

A seven-point Likert scale is utilised in the PENS questionnaire and all items are weighted equally in scoring, with only two reverse-scored items. The response options on the Likert scale were: (1) 1 = strongly agree; (2) 2 = mostly disagree; (3) 3 = somewhat disagree; (4) 4 = neither agree nor disagree; (5) 5 = somewhat agree; (6) 6 = mostly agree; and (7) 7 = strongly agree. The main question stem for all questions was: “Reflect on your play experiences and rate your agreement

with the following statements:" (Rigby & Ryan, 2007). The five areas and subscales of the PENS questionnaire are: (1) competence; (2) autonomy; (3) relatedness; (4) presence/immersion; and (5) intuitive controls.

The questionnaire was administered as a paper-and-pencil version and after the initial six-week intervention period only, at which point the complete sample who took the PENS questionnaire was n = 43 (see Table 5.7). The rationale was that participants would remember aspects of the intervention more freshly compared to a post-study point. One of the key protocol elements for *Study* 2 was to provide a detailed orientation and introduction to the intervention application (Fitocracy) for each participant and guide them through the set-up of their personalised profile page. Participants had the opportunity to ask questions and to request further training. However, none of the intervention group participants were forced to use Fitocracy providing each participant with autonomy in relation to adoption, usage and engagement.

As noted, 12.19% of the entire intervention group did not adopt Fitocracy at all at any point, another 7.3% did not adopt it until after the initial six-week intervention and 29.26% logged into the application only once. In relation to the PENS questionnaire, this means that 19.49% of the intervention group had not engaged with Fitocracy at all (outside of the orientation and training) when asked to complete the PENS questionnaire, and 29.26% had logged in only once, and thus had not spent very much time with Fitocracy at all. One important caveat for the following data is that these participants could not opt out of the PENS questionnaire by saying they did not utilise Fitocracy at all. Instead, they responded to the questions without really knowing anything about the application.

Table 5.8 presents the mean values and standard deviation in relation to the five categories of the PENS questionnaire. The highest mean value was detected for autonomy (4.52), which places this category between four and five on the Likert scale (4 = neither agree nor disagree; 5 = somewhat agree). All other mean values fall between three and four (3 = somewhat disagree).

Due to the identified subgroups within the intervention group (non-users, one-time users and regular users), the PENS data was stratified accordingly to easily compare the groups (Table 5.9). To reflect the average scores for each PENS question item, Table 5.10 provides a detailed summary overview of all of the individual question items' average scores for the three different stratified groups. The results show that all three stratified groups had similar results for each question, representative of the mean values for the whole group (Table 5.8).

The only notable difference can be found for questions eight and nine, within the presence and immersion category. The group without non-users and one-time users reported higher for experiencing genuine pride when accomplishing something with the Fitocracy intervention application and lower on perceiving events and characters within Fitocracy as if they were real. The fact that participants who actually engaged with Fitocracy experienced genuine pride in relation to accomplishments is not surprising, as the other groups would not have had any accomplishments due to no or low usage of the application.

Participants generally gave much lower scores on presence and immersion items within the PENS questionnaire. This may be an artefact of the PENS questionnaire being designed for assessing player experience within games, rather than gamefully designed applications.

Table 5.5: Fitocracy Adoption, Usage and Retention per Participant

	# of PA days		# of groups		People following		Followers		Points		Badges		Levels	
P.	6 w	6 m	6 w	6 m	6 w	6 m	6 w	6 m	6 w	6 m	6 w	6 m	6 w	6 m
1	8	8	**6**	**7**	**15**	**17**	**13**	**58**	**9344**	**24329**	**3**	**5**	**10**	**15**
2	**6**	**8**	5	5	6	6	1	1	**532**	**684**	1	1	3	3
3	0	7	6	6	6	6	**1**	**2**	**0**	**1013**	1	1	**1**	**4**
4	1	1	**6**	**7**	6	6	2	2	13	13	1	1	1	1
5	7	7	**9**	**10**	8	8	**4**	**6**	**1544**	**5338**	**1**	**2**	**4**	**7**
6	0	0	5	5	7	7	2	2	0	0	1	1	1	1
7	6	6	10	10	9	9	**6**	**7**	637	637	3	3	3	3
8	**6**	**10**	**5**	**6**	7	7	2	2	**625**	**1466**	**1**	**2**	**3**	**4**
9	**7**	**10**	5	5	12	12	2	2	**482**	**1493**	**1**	**2**	**3**	**4**
10	0	0	6	6	7	7	**3**	**4**	0	0	1	1	1	1
11	**3**	**6**	6	6	7	7	1	1	**654**	**1508**	**1**	**2**	**3**	**4**
12	**1**	**2**	**6**	**8**	7	7	1	1	**32**	**70**	1	1	1	1
13	**1**	**10**	6	6	7	7	**3**	**7**	**356**	**5443**	**1**	**2**	**3**	**8**
14	1	1	5	5	7	7	**3**	**4**	2700	2700	1	1	6	6
15	1	1	6	6	7	7	4	4	234	234	1	1	2	2
16	1	1	6	6	7	7	1	1	344	344	1	1	2	2
17	**0**	**1**	5	5	7	7	**1**	**2**	0	0	1	1	1	1
18	1	1	6	6	7	7	**2**	**3**	204	204	1	1	2	2
19	4	4	6	6	6	6	**4**	**5**	141	141	2	2	2	2
20	**0**	**4**	**6**	**7**	6	6	6	6	**0**	**567**	**1**	**2**	**1**	**3**
21	**6**	**7**	7	7	6	6	**6**	**5**	**1235**	**2287**	2	2	**4**	**5**
22	4	4	6	6	7	7	6	6	2354	2354	2	2	5	5
23	1	1	6	6	6	6	4	4	61	61	1	1	1	1
24	10	10	8	8	6	6	1	1	**1612**	**2055**	2	2	5	5
25	**10**	**127**	**7**	**8**	1	1	1	1	**1857**	**12647**	**2**	**4**	**5**	**11**
26	2	2	7	7	6	6	1	1	177	177	1	1	2	2
P.	6 w	6 m	6 w	6 m	6 w	6 m	6 w	6 m	6 w	6 m	6 w	6 m	6 w	6 m
27	**9**	**74**	7	7	5	5	**2**	**4**	**15752**	**38593**	**2**	**4**	**12**	**18**
28	1	1	8	8	6	6	2	2	162	162	1	1	2	2
29	1	1	10	10	6	6	3	3	636	636	1	1	3	3
30	6	6	7	7	1	1	1	1	291	291	2	2	2	2
31	0	0	7	7	1	1	1	1	0	0	1	1	0	0
32	**3**	**27**	8	8	1	1	1	1	**633**	**7148**	**1**	**3**	**3**	**9**
33	1	1	7	7	6	6	**2**	**1**	156	156	1	1	2	2
34	0	0	8	8	1	1	**1**	**2**	0	0	1	1	1	1
35	1	1	7	7	1	1	1	1	261	261	1	1	2	2
36	1	1	8	8	1	1	1	1	48	48	1	1	1	1
37	0	0	7	7	1	1	1	1	0	0	1	1	1	1
38	1	1	7	7	1	1	1	1	351	351	1	1	3	3
39	**10**	**13**	8	8	1	1	1	1	**3834**	**4183**	2	2	**6**	**7**
40	**2**	**5**	8	8	1	1	1	1	**622**	**915**	2	2	**3**	**4**
41	**10**	**67**	8	8	1	1	1	1	**7060**	**18428**	**2**	**13**	8	8
chan-ges	15		7		1		14		18		11		114	

Table 5.6a: Adoption, Usage and Retention of Days of Physical Activity Tracked

	# of PA days			Change at 6 weeks	Change at 6 months
Participant	**Baseline**	**6 weeks**	**6 months**		
1	0	8	8	Yes	No
2	0	6	8	Yes	Yes
3	0	0	7	No	Yes
4	0	1	1	Yes	No
5	0	7	7	Yes	No
6	0	0	0	No	No
7	0	6	6	Yes	No
8	0	6	10	Yes	Yes
9	0	7	10	Yes	Yes
10	0	0	0	No	No
11	0	3	6	Yes	Yes
12	0	1	2	Yes	Yes
13	0	1	10	Yes	Yes
14	0	1	1	Yes	No
15	0	1	1	Yes	No
16	0	1	1	Yes	No
17	0	0	1	No	Yes
18	0	1	1	Yes	No
19	0	4	4	Yes	No
20	0	0	4	No	Yes
21	0	6	7	Yes	Yes
22	0	4	4	Yes	No
23	0	1	1	Yes	No
24	0	10	10	Yes	No
25	0	10	127	Yes	Yes
26	0	2	2	Yes	No
27	0	9	74	Yes	Yes
28	0	1	1	Yes	No
29	0	1	1	Yes	No
30	0	6	6	Yes	No
31	0	0	0	No	No
32	0	3	27	Yes	Yes
33	0	1	1	Yes	No
34	0	0	0	No	No
35	0	1	1	Yes	No
36	0	1	1	Yes	No
37	0	0	0	No	No
38	0	1	1	Yes	No
39	0	10	13	Yes	Yes
40	0	2	5	Yes	Yes
41	0	10	67	Yes	Yes

Table 5.6b: Adoption, Usage and Retention of Days of Physical Activity Tracked: Summary

	No adoption at all	Adoption only after initial six-week intervention	Initial adoption & usage during first six weeks, but no retention after six weeks	Initial adoption & usage during first six weeks & retention at six months
Participants	5	3	20	13
Details		low usage for all 3	12 out of 20 only logged in once during the first six weeks, not representing actual usage, but simply trying it once	Only 4 out of the 13 demonstrated significant usage over the six-month period (27, 67, 74 and 127 logins respectively)

Table 5.7: Mean (SD) of PENS Subscales in Intervention Group

	N	Mean Values	Standard Deviation
Competence	43	3.91	1.36
Autonomy	43	4.52	1.06
Relatedness	43	3.14	0.89
Presence	43	3.05	0.95
Control	42	4.03	1.46

Table 5.8: Mean Values of PENS Subscales for Stratified Groups

(all numbers represent mean values)	All participants	Minus non-users	Minus non-users & one-time users
Competence	3.91	3.94	3.90
Autonomy	4.52	4.49	4.65
Relatedness	3.14	3.15	3.16
Presence	3.05	2.94	2.80
Control	4.03	4.04	3.92

This indicates two things: an opportunity to adapt and/or develop a specialised questionnaire to assess user experience for gamefully designed applications and an opportunity for designers of gamefully designed applications. When matching the taxonomy of game-derived situated motivational affordances to the feature list of Fitocracy (Chapter 3), we found that presence and immersion-related SMAs like open-world designs are not present within Fitocracy. This gap may present the possibility of impact for greater user engagement as Fitocracy was found to not contribute to high levels of presence and immersion.

Based on the Likert scale results, the PENS questionnaire overall showed that on average, participants did not find Fitocracy intrinsically motivating. Even by stratifying the groups by sorting out non-users and one-time users, the results did not change drastically, remaining at levels that indicate that even those individuals

who used Fitocracy more frequently did not find the application intrinsically motivating (Table 5.8).

Table 5.9: PENS Detailed Summary Overview

	All participants (Mean Values)	**Minus non-users** (Mean Values)	**Minus non- & one-time users** (Mean Values)
Competence	**N = 43**	**N = 36**	**N = 23**
1. I feel competent at Fitocracy.	4.07	4.08	3.96
2. I feel very capable and effective when using Fitocracy.	4.72	4.64	4.82
3. My ability to use Fitocracy is well matched with the game's challenges.	3.18	3.27	3.3
Autonomy	**N = 43**	**N = 36**	**N = 23**
1. Fitocracy provides me with interesting options and choices.	3.7	3.69	3.6
2. Fitocracy lets you do interesting things.	4.56	4.53	4.87
3. I experienced a lot of freedom in Fitocracy.	3.06	3.14	3.3
Relatedness	**N = 43**	**N = 36**	**N = 23**
1. I find the relationships I form in Fitocracy fulfilling.	3.86	3.94	3.97
2. I find the relationships I form in Fitocracy important.	4.18	4.12	4.26
3. I don't feel close to other players (reverse scored item)	4.83	5	5.13
Presence/Immersion	**N = 43**	**N = 36**	**N = 23**
1. When using Fitocracy, I feel transported to another time and place.	2.81	2.55	2.21
2. Exploring the Fitocracy world feels like taking an actual trip to a new place.	2.9	2.86	2.74
3. When moving through the Fitocracy world I feel as if I am actually there.	2.74	2.58	2.34
4. I am not impacted emotionally by events in Fitocracy (reverse scored item).	5.37	5.44	5.48
5. Fitocracy was emotionally engaging.	3.42	3.33	3.3
6. I experience feelings as deeply in Fitocracy as I have in real life.	2.69	2.5	2.3
7. When playing Fitocracy I feel as if I was part of the story.	2.69	3.05	2.74
8. When I accomplished something in Fitocracy I experienced genuine pride.	3.09	4.36	4.48
9. I had reactions to events and characters in Fitocracy as if they were real.	4.37	2.66	2.5
Intuitive Controls	**N = 43**	**N = 36**	**N = 23**
1. Learning the Fitocracy controls was easy.	3.95	3.88	3.7
2. The Fitocracy controls are intuitive.	4	4	3.91
3. When I wanted to do something in Fitocracy, it was easy to remember the corresponding control.	3.86	3.88	3.65

5.2.3.4 Interviews

In addition to quantitative data, semi-structured interviews were conducted to provide a deeper insight into the acting and underlying mechanisms leading to the observed data. Interviews provide a more complete picture of the potential

influencing factors contributing to the changes in physical activity and to the concepts and themes related to motivational factors that can be explored more fully in the context of a narrative. We intentionally opted for a rigorous, theory-grounded mixed-methods approach to respond to the lack of rigorous research on the effectiveness of gameful design within physical activity applications (see Chapter 2).

Semi-structured interviews were designed to capture information specifically relevant to the following objectives: evaluating the quality of the intervention implementation*;* evaluating the mechanisms of impact on motivation for physical activity; evaluating the influence of external factors on the delivery and functioning of the intervention and assessing the effectiveness of the delivery mechanisms of the intervention conducted.

5.2.3.4.1 Interview Settings

Interview participants were given four options for meeting locations: the LLU study centre, Centennial Hall or Nichol Hall on the campus of LLU or the Health and Exercise Science office on the campus of La Sierra University. Locations were chosen to provide: (1) accessibility; (2) parking options; (3) privacy; and (4) considerations for sound quality for recording purposes. All interview settings had a table and chairs as well as natural light, providing a comfortable and non-intimidating environment.

5.2.3.4.2 Participants

In total, 15 intervention group participants were interviewed. Stratification for the selection of interview candidates was undertaken in relation to physical activity levels (MVPA) based on the three-month data collection point. Three categories were identified: (1) shows increase of MVPA of minimum average of plus 10 minutes per day from baseline value; (2) remains within 10 minutes of MVPA per day of baseline value; and (3) shows decrease of minimum average of minus 10 minutes per day of baseline value (see Table 5.10). Based on these categories, five participants in the intervention group were identified to represent category one, five were selected to represent category two and four others were selected to represent category three. One individual for whom no data for MVPA at three months was available due to malfunctioning of the accelerometer also agreed to be and was interviewed.

Table 5.10 outlines the three stratified groups plus the one additional interviewee. For MVPA at six weeks and three months, the numbers in parentheses represent the respective changes of MVPA in minutes per day on average. Although stratification was based on the three-month data collected, Table 5.10 also includes six-week MVPA data to show the various differences in activity levels immediately following the six-week intervention compared with the MVPA levels at three months.

The interviews were conducted within three months after the six-month data collection point, which was approximately four-and-a-half months after the completion of the six-week intervention. Although the intervention occurred during the first six weeks of the entire research study, participants in the intervention group continued to have access to the intervention application (Fitocracy) throughout the entire six months. Thus, it was important to conduct the interviews after the complete six-month period in order to obtain valuable information regarding adoption, retention and usage of the application over the longer term. As this research study employed a rolling enrolment method, participants finished

at different time points; however, the abovementioned timeframe was applicable to all interviewees.

5.2.3.4.3 Consent and Invitation
All research participants signed a consent form prior to enrolling in the study, whereby they agreed to being contacted for possible interviews during the study process. As soon as a participant completed the last data collection appointment after the six-month period, they were asked whether they would be willing to be interviewed by the primary investigator of the study. Immediately after a potential interview candidate was stratified to any of the three groups, they were contacted via email, phone call or text message by the primary investigator to set up an interview appointment.

5.2.3.4.4 Interview Design and Procedures
An interview guide was designed by the main research investigators and organised in themes according to the objectives for *Study 3* (Appendix 5.2). Table 5.11 depicts key questions and themes for exploration utilised during the interview process. The usage of semi-structured interviews allowed for the exploration of themes with follow-up questions through the interview with the individual participants.

Interviews were audio-recorded utilising the voice memo function on an iPhone 5s and an Olympus digital voice recorder as a backup method. Audio files were identified by participant research ID and immediately transferred to a password-protected computer file on one of the designated research laptops and also onto an external hard drive dedicated to storing research data as a backup method. The laptops and external hard drive were stored in a locked file cabinet accessible only to the research team. Immediately after the transfer of files, the audio files were deleted from the iPhone and the digital voice recorder. All audio data was kept secure and stored according to LLU IRB regulations. LLU IRB stipulates the secure storage of data as indicated above for a minimum of five years post-fieldwork.

5.2.3.4.5 Transcription
Transcription of the audio files was done word for word by four different research team members, all utilising the same format of transcription: (1) primary investigator; (2) two senior research assistants; and (3) a trained transcriptionist added to the research team. Transcription occurred as interviews were completed. All transcription documents were then reviewed by the primary investigator and stored in password-protected, secure digital locations. No hard copies of the transcriptions were produced at any time point, allowing secure data storage at all times.

5.2.3.4.6 Methods and Data Analysis
The Framework Method was employed to analyse the data obtained from the interviews. This method for qualitative data analysis (Ritchie & Lewis, 2003) has more recently gained popularity within healthcare research due to its systematic approach (Smith & Firth, 2011). One of the key aspects of the Framework Method is that it provides transparency related to the analytical processes taking place within qualitative data analysis (Ritchie & Lewis, 2003). Seven interconnected stages guide the procedures for analysis: (1) transcription; (2) familiarisation with the interview; (3) coding; (4) developing a working analytical framework; (5) applying the analytical framework; (6) charting data into the framework matrix; and (7) interpreting the data. The Framework Method has most frequently been applied to the thematic analysis of semi-structured interviews (Gale et al., 2013),

and thus offers a suitable well-defined and evidence-based framework for this data analysis.

Familiarisation with the interview transcripts occurred by reviewing and re-reading the interview transcripts. Since the interview guide was laid out thematically, organised by the objectives for *Study 3*, the initial coding structure was pre-defined, as is common with deductive studies having specific interests related to a project or study (Gale et al., 2013). Five clear themes framed the interview guide (Table 5.11), also forming the initial coding structure for the purpose of the data evaluation (Table 5.12). Initial code 1, reasons why participants chose to enrol in the study, had a dual purpose, namely to make the participant feel more comfortable and also to obtain some initial insight into the individual's attitude related to physical activity.

Table 5.10: Interviews - Intervention Group

Stratification	**Participant ID** (gender & age)	**Date**	**MVPA – B** (average per day for 7 days)	**MVPA – 6W** (average per day for 7 days)	**MVPA – 3M** (average per day for 7 days)	**Weight – 3M**	**Fitocracy Track PA (6 weeks & 6 months)**	
Increase of minimum average of +10 min/day at 3 months	I1 (F, 44)	07/15/15	74.4	96.6 (+24.1)	115.7 (+41.3)	+0.7 kg	6	7
	I2 (F, 25)	07/15/15	99.1	Missing	131.7 (+32.6)	+0.8 kg	0	4
	I3 (F, 44)	06/19/15	128	164.6 (+36.6)	153.7 (+25.7)	-0.6 kg	8	8
	I4 (M, 39)	07/16/15	123.9	136.3 (+12.4)	146.1 (+22.3)	-0.9 kg	1	1
	I5 (M, 32)	06/16/15	215	230 (= +15)	225.7 (+10.7)	+1.7 kg	0	7
Within 10 min/day of baseline at 3 months	N1 (F, 38)	06/04/15	125.9	192 (+66.1)	135.1 (+9.3)	-0.5 kg	6	8
	N2 (F, 25)	06/22/15	80.1	82.5 (+2.4)	79.7 (-0.4)	+2.2 kg	7	10
	N3 (F, 39)	06/25/15	130.7	92 (-38.7)	127.6 (-3.1)	+2.9 kg	0	0
	N4 (F, 29)	06/30/15	144.4	157 (= +12.6)	140 (-4.4)	-1.4 kg	0	1
	N5 (F, 40)	06/23/15	119.3	122.4 (+3.1)	112.9 (-6.4)	-0.1 kg	6	6
Decrease of minimum -10 min/day at 3 months	D1 (F, 25)	06/23/15	180.3	153.4 (-26.9)	167.3 (-13)	-2.6 kg	6	10
	D2 (F, 26)	06/23/15	170.7	120 (-50.7)	156.3 (-14.4)	-3.1 kg	1	2
	D3 (M, 36)	06/18/15	115.1	139.3 (+24.1)	91.3 (-23.9)	+1.9 kg	1	1
	D4 (F, 43)	06/24/15	221	236.1 (+15.1)	157 (-64)	+ 1 kg	1	10
No data at 3 months	Extra (F, 34)	06/05/15	207.3	208 (= +0.7)	Missing	-0.3 kg	7	7

Note: The participant ID numbers were created specifically for the interview analysis

Table 5.11: Interview Guide Key Questions

Key Interview Questions	Themes of Exploration
1. Why did you participate in this research study?	Motivation to enrol in the study.
2. What helped you in your effort to increase your physical activity?	Motivators and drivers in relation to physical activity behaviour.
3. What obstacles did you experience trying to be physically active?	Barriers and obstacles in relation to physical activity behaviour.
4. Can you just walk me through the process of how you used Fitocracy so far, from the first day of the study to today?	Motivational factors related to the intervention application and user experience with the intervention application.
5. How was your experience participating in this study?	All factors impacting user experience in relation to the entire study protocol.
6. If you could make any changes to this research study process in the future, what would you change in relation to: a) accelerometers; b) questionnaires; c) Fitocracy; d) locations; and e) research staff?	User experiences specifically related to administrative processes of executing the intervention.

Further, this theme presented opportunities to probe actual personal motivations for wanting to be more physically active. Initial code 2 represents the questions related to potential motivators and drivers for physical activity that participants could identify. Initial code 3 focused on the various barriers and obstacles preventing participants from engaging in physical activity. Related, yet slightly different, initial codes 4 and 5 centralised questions on the participant's experience with the intervention application (Fitocracy) and the entire study protocol at large. The Qualitative Data Analysis Software MAXQDA was utilised for the purpose of coding and organising the data.

Table 5.12: Initial Coding Structure

Initial Codes (IC)	Description
IC 1	Motivation for enrolling in the research study
IC 2	Motivators and drivers for physical activity behaviour
IC 3	Barriers and obstacles to physical activity behaviour
IC 4	User experience related to Fitocracy
IC 5	User experience related to the entire study protocol

5.2.3.4.7 Results and Findings

The initial coding structure was utilised to code the first four interviews to determine whether more specific codes would emerge. This process is an important factor in the development of an analytical framework as part of the data evaluation procedure (Gale et al., 2013). As expected, several additional codes did indeed emerge during the preliminary coding process of the first four interviews. Table 5.13 presents these emerging codes, which represent more specific aspects of the initial themes, but are mostly focused on initial codes 4 and 5, since they were a bit more general in nature to begin with than the others.

Table 5.13: Emerging Codes

Emerging Codes (EC)	Description
EC 1	Initial reaction to Fitocracy
EC 2	Enjoyment aspects related to Fitocracy
EC 3	Dislikes related to Fitocracy
EC 4	Usage of the overall Fitocracy application
EC 5	Feature usage within Fitocracy
EC 6	Competence factors related to Fitocracy and physical activity skills
EC 7	Relatedness factors within and outside of Fitocracy in relation to physical activity
EC 8	Attitude toward and opinions about accelerometer usage
EC 9	Attitude towards and perceptions regarding the questionnaires assessing motivation for physical activity
EC 10	Opinions about and suggestions for assessment appointments
EC 11	Opinions about and suggestions for assessment location
EC 12	Opinions about and suggestions for research staff

The main research team (primary investigator and two co-investigators) reviewed the initial and emerging codes and agreed on the creation of the analytical framework, specifically designed for this study's analysis (Figure 5.1 and 5.2). The preliminary evaluation of all the codes brought forth two domains: A) mechanisms of impact affecting motivation for physical activity and physical activity levels; and B) participant experience of intervention application and intervention processes. Categorised underneath each domain are the various thematic codes matched with initial and emerging codes identified previously. Notably, two codes under domain A and B are very similar, namely A4 and B1 (Fitocracy-related codes) and A6 and B2 (accelerometer-related codes). Although, at first glance, these may appear to be duplicates, these codes were placed intentionally under each of the categories respectively. Domain A is concerned with aspects related to mechanisms of impact affecting motivation and physical activity behaviour. Domain B is focused on the experience of the user. Fitocracy and the accelerometers, respectively, have important different angles for each theme.

A detailed table for each specific code with direct participant quotes, and with underlined and highlighted significant statements, can be found in Appendix 5.3. All interview transcripts were coded using the initial and emerging code structures outlined in the analytical framework (Figures 5.1 and 5.2), referring to stage five of the Framework Method (Gale et al., 2013).

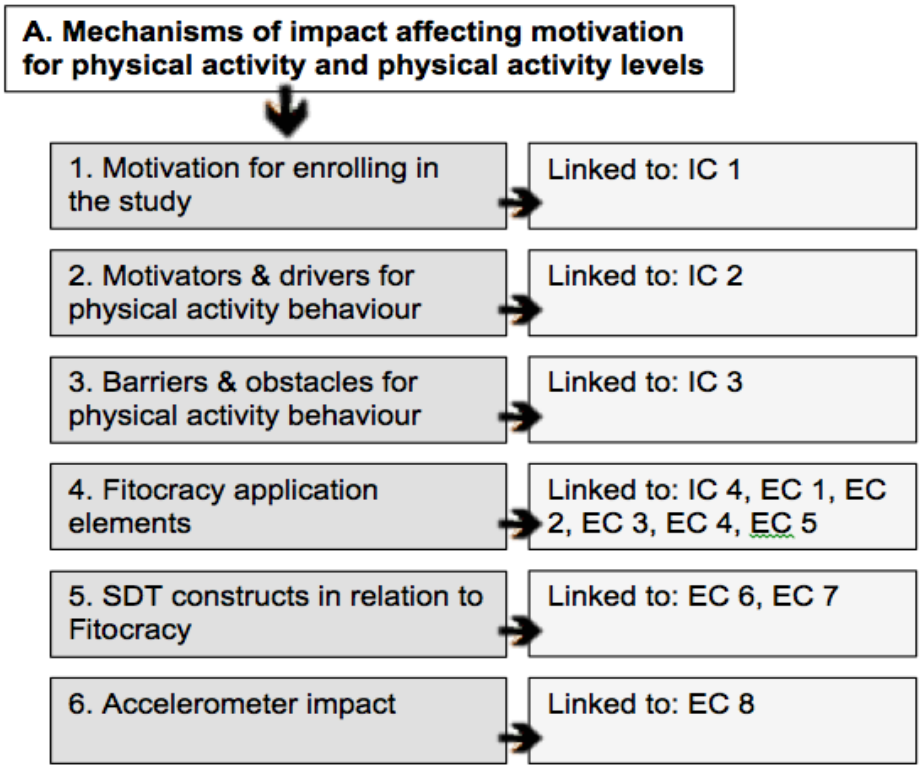


Figure 5.1: Analytical Framework Part I

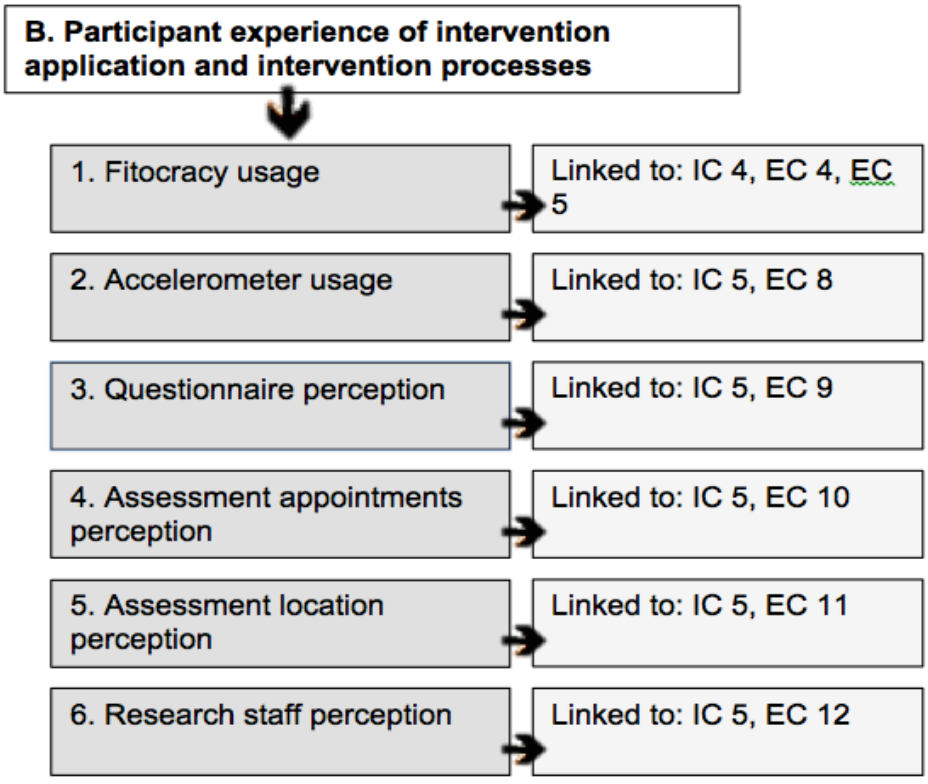


Figure 5.2: Analytical Framework Part II

5.2.3.4.8 Domain A: Mechanisms of Impact

Motivation for Enrolling in the Study
Out of the 15 interviewees, 13 individuals expressed reasons and motivations for enrolling in the study; however, they all varied significantly. Eight interviewees hoped for assistance with physical wellness, such as losing weight or becoming more fit or more physically active: *"I thought it [the study] would motivate me to lose weight"* (I4, M, 39); *"I thought it [the study] would be a good opportunity to increase my level of physical fitness or physical activity"* (D1, F, 25).

Six indicated the desire to contribute to something positive and to give back as a volunteer for the study: *"I felt like I was contributing to something positive"* (I2, F, 25); *"It's part of that giving back thing for me"* (I3, F, 44). One interviewee expressed curiosity about the research study itself and another was looking for a fun new experience. This variation of motivations to enrol in the research study was true across all of the stratified groups without identification of specific trends within a particular group.

Motivators and Drivers for Physical Activity Behaviour
Motivators and drivers for physical activity behaviour among the interviewees also varied. Four thematic groupings were identified across all three stratified interview groups: (1) people/animals; (2) body weight; (3) fear of physical disability, disease or pain; and (4) accountability. Although listed separately, a connection between people/animals and accountability could be detected for some: *"…being accountable to somebody or something maybe sparks that motivation a little bit more…"* (N5, F, 40); *"I need an instructor and we're going to be there and she'll lead me through"* (I3, F, 44).

"People/animals" represented the greatest motivator or driver: *"…and my daughter, she is my biggest motivator"* (D2, F, 26); *"…it was my husband…"* (I1, F, 44); *"…having friends or even family members or whoever that I can exercise with is a big thing for me…"* (D3, M, 36). This discovery represents consistency with the basic psychological need for relatedness according to SDT, namely that it plays a vital part in influencing motivation for behaviour, in this case, physical activity behaviour.

The second theme was body weight: *"I hate gaining weight"* (N2, F, 25); *"… before I was pregnant, I weighed about 150 pounds. I now weigh about 190. So that's a huge motivator"* (D2, F, 26). Although it did not represent the majority of participants, some fear regarding physical disability was reported: *"I see on the street or at the store people walking with a walker and think, I don't want that to happen to me"* (N1, F, 38). In addition to the people/animal and accountability connection noted earlier, other accountability factors appeared to act as drivers for some of the participants: *"…just the fact that I knew someone, "big brother", was watching was kind of a motivator…"* (D2, F, 26); *"…going to the class at 5 a.m. and marking off on Fitocracy, those 2 things together worked really well…"* (I3, F, 44).

Notably, not one interviewee noted games or gamefully designed features as a driver or motivator to become or stay physically active. Only one participant, as referenced above, indicated Fitocracy in some way as being a motivator.

There is one clear connection between the first initial code (motivation for enrolment in the study) and this second initial code (motivators and drivers for physical activity), namely the desire to make physical changes, motivation to lose

weight or to become more physically fit. Indirectly, the fear of physical disability or disease relates to this theme, focused on the physical wellbeing motivating the desire to be physically active. It is not clear which of the participants were motivated strictly by aesthetic outcomes of physical change and which were driven by the idea of physical health and wellbeing related to quality of life; however, this subject dominated the answers.

Barriers and Obstacles for Physical Activity Behaviour

The variety of barriers and obstacles discovered during the coding process was vast. Some participants outlined situational obstacles: *"…just gone through a break-up" (I2, F, 25);* some displayed chronic challenges: *"…daily work-related fatigue"* (N1, F, 38); *"…school schedule, single mom, four kids…"* (I3, F, 44); two interviewees indicated simple laziness being a factor: *"I'm a little bit of a lazy person"* (D3, M, 36); *"…laziness…"* (N2, F, 25). Generally, the barriers identified correspond directly with some of the ten most common reasons adults provide for not being physically active (Sallis & Hovell, 1990), namely: lack of time, lack of social influence for physical activity, lack of energy, lack of motivation, injury and family obligations.

One participant showed true vulnerability: *"…going to the gym or exercising makes me feel embarrassed because I know that I am not like other people would be…"* (N5, F, 40). Based on the fact that participants had to be physically inactive to qualify for this study, it is interesting to observe that only one individual commented on the insecurity related to body image as affecting exercising in public. This intervention did not require anyone to exercise in public or go to the gym; however, it seems that this individual perceived this as being a necessity in order to start exercising. One particular interviewee's answer stood out in its honesty: *"…being healthy and being active isn't a priority for me…"* (I5, M, 32); intriguingly, he actually increased his activity levels more than 15 minutes on average at six weeks and still maintained a physical activity level increase of more than 10 minutes per day at three months.

Every single interviewee noted at least one barrier to becoming or being physically active, even those who increased their physical activity levels. Similarly, all interviewees indicated at least one driver or motivator for physical activity. Hence, even though all interviewees faced known obstacles and barriers, for some, the drivers and motivators outweighed the obstacles during the first three months of the research study enough to impact behaviour. However, only one interviewee indicated the intervention application (Fitocracy) being a motivator or driver and that particular participant actually increased MVPA levels by more than 10 minutes on average per day during the first three months of the study. No one else credited the intervention application with being a motivator or a driver, although some utilised it several times throughout the study.

Fitocracy Application Elements

The initial reaction to Fitocracy was generally not very excited or positive. The majority of the interviewees appeared to be mostly indifferent: *"I didn't really care about that [Fitocracy]"* (I5, M, 32); *"I didn't find it [Fitocracy] interesting"* (N4, F, 29). However, some seemed to be intrigued: *"I didn't know anything about the program, but I thought we'll do this and see what starts to happen…"* (I3, F, 44); *"…initially, I kind of liked the idea of the Fitocracy app"* (D1, F, 25); *"…at first I was like, this is kind of cool"* (D2, F, 26).

Four of the 15 interviewees used Fitocracy only once or not at all during the six-month data collection period. The interviews revealed that out of the four, one

indicated no interest in the application upon introduction and one did not like it based on first impressions. Thus, no further usage ensued and no further mechanisms of impact, intervention quality or quality of delivery mechanisms can be detected from the interviews of these four participants.

It is noteworthy that interviewee N3 never once used Fitocracy, but still indicated that the social support on the application was enjoyable. Clearly, an assumption here can be made that this participant was simply saying that social support in relation to becoming and staying physically active is valuable to him or her, but obviously this cannot be a conclusion from the actual intervention application since she never utilised it.

Six interviewees explained during the interviews that the key feature they used was the tracking of physical activity option, which is the main concept of Fitocracy, and upon which many of the situated motivational affordances hinge: *"I liked tracking"* (D3, M, 36); *"I like the fact that they have a calendar that you can go back and log days if you skipped a day and log it…"* (D1, F, 25). However, across the board, very low interest in all the other features within Fitocracy was reported.

The idea of connecting with strangers and not being face-to-face with other people throughout the process of the study seemed to be of significance for several interviewees: *"…you were supposed to connect with strangers online…"* (N1, F, 38); *"I like the face-to-face interaction…"* (D3, M, 36). Further, the idea of tracking physical activity manually and engaging with other features within Fitocracy seemed to be a burden and required too much effort for several participants: *"…it was just like documenting too much…"* (I3, F, 44); *"It just added more stuff for me to do…"* (N5, F, 40).

The overall usage of Fitocracy was very low, with 10 times being the highest number of logins among the interview sample. Over a six-month period, that represents an average of 1.6 times per week. Regular daily engagement with Fitocracy was absent among the interviewee group, thus leading to the possible conclusion that the available situated motivational affordances within the application may not have provided sufficient motivation for these participants to engage with it more frequently.

Based on the data, it is clear that Fitocracy minimally impacted motivation for physical activity and perhaps not at all. There are likewise no clear linkages between quantitative data (see above) and qualitative themes. It appears that Fitocracy usage and physical activity levels are not correlated and that increase in physical activity for five of the interviewees was the result of external factors unrelated to the Fitocracy application. It also appears that every participant's scenario was unique and that physical activity behaviour was dependent on various mechanisms of impact, some of them being external motivators and drivers, some of them being obstacles and barriers, some of them being aspects of the research study and some of them being related to Fitocracy, such as the tracking feature. To illustrate the various Fitocracy-related information, some from the quantitative data and some from the interviews, Table 5.14 displays several columns of information: number of logins to Fitocracy at six weeks and six months, initial reaction to Fitocracy, which features were utilised, whether participants enjoyed or disliked Fitocracy (some listing more specifics to either) and lastly a column related to the concept of competence and one concerned with relatedness.

SDT Constructs Related to Fitocracy

Although very little information was captured regarding competence and Fitocracy, some interviewees expressed concern: *"…it wasn't easy for me. Maybe I'm just not savvy when it comes to these applications"* (I1, F, 44); *"…it was more difficult to use than it had first appeared…"* (N1, F, 38) *"…most of the challenges were way ahead of my level…"* (N5, F, 40). Another interviewee angrily explained during the interview that logging in the first time and seeing others had accumulated large amounts of points was immediately discouraging and frustrating, impacting his perceived abilities to catch up to the others and therefore his willingness to use the application: *"…the first thing I saw was there was someone in there who had this massive amount of points. And if you don't exercise and the first thing you see is someone with 5000 points, forget it, what's the point, I don't want to compete with you"* (I4, M, 39). This indicates that the application itself made the participant feel incompetent, which can directly thwart intrinsic motivation (Ryan & Deci, 2000).

Interviewees felt a lack of competence in relation to using the Fitocracy application from a technological perspective, referring to themselves as not particularly technologically savvy. Three individuals did not find it easy to use, whereas one other interviewee indicated that Fitocracy was very easy to navigate and user-friendly: *"…the way it works is very simple. It's very straightforward"* (Extra, F, 34). Two out of the three who did not find the application easy to use still utilised it seven and eight times respectively over a six-month period, but the other one did not continue to use it after the second attempt. The interviewee who found the application easy to use logged in approximately the same number of times as the two individuals indicated above, who found it difficult to use; thus, no utilisation differences could be detected here.

Some interviewees enjoyed the social features of Fitocracy, such as the option to join a group, the props provided by the people assigned to follow you and the tips shared by others: *"…the biggest positive was the support, the social support"* (N3, F, 39); *"I felt like there was this community of people that was excited about the same thing you were…"* (I2, F, 25). Other interviewees, however, were turned off by the idea of connecting with strangers online, indicating that it was meaningless and that privacy might be invaded that way: *"I didn't know them in real life"* (N1, F, 28); *"I have my friends, real people…"* (I3, F, 44). Two interviewees were clear regarding their preference to interact with real people on a face-to-face basis, rather than connecting with strangers on cyberspace. Yet another interviewee expressed the desire to try the Fitocracy application along with other friends from real life to begin with more meaningful immediate connections: *"…maybe if there were five of us friends that said we would do this [Fitocracy] together and we would compete and then, perhaps then I would track…"* (D4, F, 43). It is noteworthy that quite a few interviewees indicated real people as drivers and motivators for physical activity previously, which is a re-emerging theme here.

Accelerometer Impact

A mechanism of impact for some participants was identified as the accelerometer devices themselves: *"…for me it [accelerometer] helped me with positive pressure"* (N5, F, 40). Although some disliked the look and feel of this measurement tool, it appeared to have an impact on the daily conscious thought process in relation to physical activity for some participants. One interviewee referred to the concept of *"big brother is watching"* (D2, F, 26), providing a visual daily reminder via the accelerometer, that something is being recorded that someone may see, so more effort is required. Two interviewees even suggested the accelerometer be required to wear for longer periods of time, as it seemed

beneficial to them: *"I felt like maybe I could keep it on longer…"* (I1, F, 44); *"I wish we would have longer than just a week"* (N5, F, 40).

5.2.3.4.9 Domain B: Participant Experiences

Fitocracy Usage
Further findings from the interview process relate to the participants' experiences with the intervention application (Fitocracy) and with the research study process overall, informing the main evaluation aims of *Study 3.* Six codes were identified and selected as part of Domain B of the analytical framework: (1) Fitocracy usage; (2) accelerometer usage; (3) questionnaire perception; (4) assessment appointments perception; (5) assessment location perception and (6) research staff perception.

Table 5.14 shows the various usage frequencies of Fitocracy among all participants, which overall was minimal. Domain A of the interview analysis confirmed that the Fitocracy application overall did not generate much enthusiasm or sustain interest. The only feature that seemed to get more usage was the tracking option. The interviews provided helpful, honest descriptions of experiences participants had with Fitocracy: *"To me at this stage, a badge and points, I'm just not interested in playing that game"* (I3, F, 44); *"It [Fitocracy] was cute and fun but then I kept forgetting, so I was like, forget about it"* (N5, F, 40); *"…it [Fitocracy] could have been good, but I didn't give it a chance"* (N4, F, 29). Participants described their perception of Fitocracy having potential and some aspects being interesting and intriguing, but still, apparently not enough to foster initial and sustained engagement at higher levels for the majority.

Accelerometer Usage
Compliance with wearing the accelerometers four times for a one-week time period was high throughout the study (Chapter 4). Several participants expressed their dislike for wearing this device for various different reasons: *"…sometimes it would get itchy…"* (N2, F, 25); *"I hated wearing it. I think I just found it frustrating"* (D2, F, 26); *"…clearly they should be smaller…"* (N3, F, 39); *"I was always trying to hide it to make it look like a bracelet or something else"* (I2, F, 25). As explained previously, some participants desired to wear it longer than one week, as they felt that wearing it provided motivation to move more, even though no actual information was visible whilst wearing it. The majority of the participants seemed to simply have an issue with the aesthetics of the device: *"…the accelerometer was so ugly…"* (I2, F, 25); *"…it was ugly…"* (I3, F, 44).

Questionnaire Perception
The delivery mechanism of the questionnaire received rather poor feedback, with repeated emphasis on the length and viewing option being the primary issues: *"I thought they were a little long and tedious"* (D3, M, 36); *"I think it was hard to scroll up and down on the screen"* (N1, F, 38). Interviewees expressed frustration about the repetitiveness of the questions, the phrasing of the questions being somewhat confusing and the rating description disappearing when scrolling down the page: *"I felt like the questions were similar, repetitive; they just switched some words around"* (N4, F, 29). Some interviewees commented that they felt confused as to why the same questionnaire was administered every time they came to the research appointment, causing self-doubt in the answers provided and potential over-analysis of the questions posed: *"I really felt confused; I felt like I was doing the same survey every visit"* (I2, F, 25). This may have had a direct impact on the questionnaire results, and thus provides important input for future randomised controlled trials, namely, that these issues need to be more clearly addressed.

One participant explicitly noted that the questions on the questionnaire made her think more closely about her current mind-set in relation to physical activity (Extra, F, 34), thus indicating a possible direct impact on levels of motivation.

Assessment Appointments Perception

Out of 15 interviewees, 13 provided information indicating that all aspects related to the various data collection appointments were positive, flexible and easy: *"It [assessment appointments] was very smooth, flexible…"* (I3, F, 44); *"…the appointment was good…"* (I4, M, 39). This finding reflects positively on the entire research team for making the research process pleasant and user-friendly. An emerging theme, vital for future implementation of a fully randomised controlled trial, is the positive reference to sending text message reminders: *"I always loved those reminders"* (N4, F, 29); *"You guys sent me reminders"* (I1, F, 44). This may have directly impacted research participation levels and the low attrition rate observed in *Study 2*.

Assessment Location Perception

Five interviewees commented on the location where the research appointments took place, all indicating a positive reaction to the convenience factor, except for the issue of parking. Having an easily accessible location for the data collection, where participants feel comfortable is important to the overall user experience and helpful input in terms of future replication: *"I felt comfortable going there"* (N4, F, 29); *"…the location was actually kind of convenient for me"* (D2, F, 26).

Research Staff Perception

Finally, interviewees provided information about their experiences with the research staff. Overall, only positive feedback was detected, with participants repeatedly reporting that research staff members were friendly, pleasant and very nice: *"…they were helpful and friendly"* (N4, F, 29); *"…everybody was great; they were all friendly"* (D2, F, 26). Further, professionalism was pointed out, which reflects superbly on the entire research team and intervention implementation process: *"…they were very friendly, very professional…"* (N2, F, 25); *"… everybody was wonderful, excellent staff"* (N5, F, 40). Positive perceptions of the interaction with the research team may have had an effect on participants' willingness to stay in the study and continue to adhere to the research appointments, again potentially accounting for the low attrition rate observed in *Study 2*.

Table 5.14: Fitocracy Coding Summary

Stratification	Participant	6 w	6 m	Initial Reaction	Features/ Usage	Enjoyment	Dislikes	Competence	Relatedness
Increase of minimum average of +10 min/day at 3 months	I1	6	7	Ok; try	track	no	N/A	not easy to use	N/A
	I2	0	4	Easy	groups	community	N/A	N/A	community
	I3	8	8	Ok; try	track, (coach)	yes	documenting too much	N/A	props
	I4	1	1	N/A	N/A	no	discouraging no privacy	-difficulty navigating	N/A
	I5	0	7	Whatever	N/A	N/A	too much work/effort	N/A	N/A
Within 10 min/day of baseline at 3 months	N1	6	8	N/A	track	robot/ humour	connecting with strangers	not easy to figure out	need real person to connect with
	N2	7	10	N/A	track	props/likes	N/A	N/A	trying to connect with other participants
	N3	0	0	N/A	N/A	support	N/A	N/A	social support
	N4	0	1	No interest	N/A	N/A	N/A	N/A	N/A
	N5	6	6	N/A	challenges	others cheering	too much work/effort	too challenging	props
Decrease of minimum -10 min/day at 3 months	D1	6	10	Ok; try	track	helpful	-difficult navigating	N/A	N/A
	D2	1	2	Ok; try	read	N/A	too much work/effort	not technology savvy	N/A
	D3	1	1	No like	N/A	tracking	N/A	N/A	need face to face
	D4	1	10	No interest	N/A	N/A	N/A	N/A	real friends doing it together
No data at 3 months	Extra	7	7	Ok; try	track	points	N/A	simple to use	want face to face

5.2.3.5 Resource Use and Costs

The last objective of the *Process Evaluation Study* was to estimate the resource use and costs associated with the *Intervention Implementation Example Case Study*. The chosen intervention application, Fitocracy, is a commercial web- and mobile-based application free of charge. Thus, the application itself did not incur any costs. However, some features within the Fitocracy application are available only for an additional charge. None of these items were required or utilised as part of this study, but would be available as an option for any future implementation.

Firstly, Fitocracy offers a monthly membership (see Figure 5.3) that provides detailed workout plans with instructions and information that change every month, a nutrition guide, motivational and educational materials, education on how to stick to your plan long-term and access to a members-only group providing support and motivation. The cost of this is low, at only seven U.S. dollars per month.

Secondly, Fitocracy offers a coaching option (see Figure 5.4), where you can obtain a personal fitness coach (real person), who interacts with you via the Fitocracy application (not face to face). The Fitocracy coaching plan includes a fitness assessment, personalised workouts, personalised nutrition plans, motivation and accountability. The site claims that the Fitocracy coach connects with you on a daily basis. Depending on the coach you choose, costs vary. Currently, there are four coaches available with whom Fitocracy participants can purchase personal training sessions. Table 5.15 displays the various coaching options and costs.

Table 5.15: Coaching Options via Fitocracy

Coach	Length of Plan	Cost
Jason	13 weeks	$59/month
Slyvon	personalised workouts for your schedule (per month)	$250/month
Miwa	16 weeks	$39/month
Allison	personalised workouts for your schedule (per month)	$98/month

Each coach offers different types of services and plans, some including daily personal attention and some weekly. Essentially this coaching service resembles online personal fitness training for purchase. Again, this Fitocracy feature was not utilised during the intervention in *Study 2*.

Lastly, another option for purchase within Fitocracy is called “Become a Hero” (see Figure 5.5). This feature costs $4.99 per month or $44.99 per year. Multiple additional Fitocracy features become available via this opportunity. Weekly insights into detailed personal workout summaries are provided once you become a Fitocracy Hero. Private messaging with other Fitocrats becomes a possibility allowing friendly words of encouragement, an exchange of information about workout routines and anything else one may like to talk about.

Further, “duels” become a possibility, allowing Fitocrats to challenge another on a one-on-one basis basically on anything they want, including most points or most distance run, to name a couple of examples. “Claiming a Title” presents another feature once one becomes a Fitocracy Hero. Titles can be claimed and unlocked

by accomplishing different milestones. Once claimed, titles will always appear underneath one's screen name.

It is possible that someone else on Fitocracy posts their own workout for others to see. In that case, as a Fitocracy Hero, you have the capability to save someone else's workout and try it yourself. Although badges are available to be earned as part of the free version of Fitocracy, exclusive badges are available only once one has become a Fitocracy Hero. Lastly, the paid option of being a Fitocracy Hero allows you to obtain early access to newly released program features and to save unlimited workout routines.

It is important to note that Fitocracy depends on participants recording workout data manually via the website or mobile-based app. Fitocracy does not require an activity tracker, nor does it integrate with one. This may limit the objectivity regarding the physical activity data. The Intervention Implementation Study (*Study 2*) employed the use of accelerometer devices to collect objective physical activity data; however, no actual tracking information was visible to the participant.

In summary, if this intervention (Fitocracy) were to be implemented in the future, organisers could utilise the free commercial option of Fitocracy, which provides access to many gamefully designed features, including: personalised profile page, personalised dashboard, points, levels, leader boards, badges, quests, access to groups, friend following an up-to-date wall with information from Fitocracy connections, performance summaries and graphs, articles and educational information. Activity trackers are not required nor do they sync with this application. There is no limit on usage or timeframe. Each participant has the freedom to engage with Fitocracy in many different ways, choosing which options may be interesting and helpful and which may not.

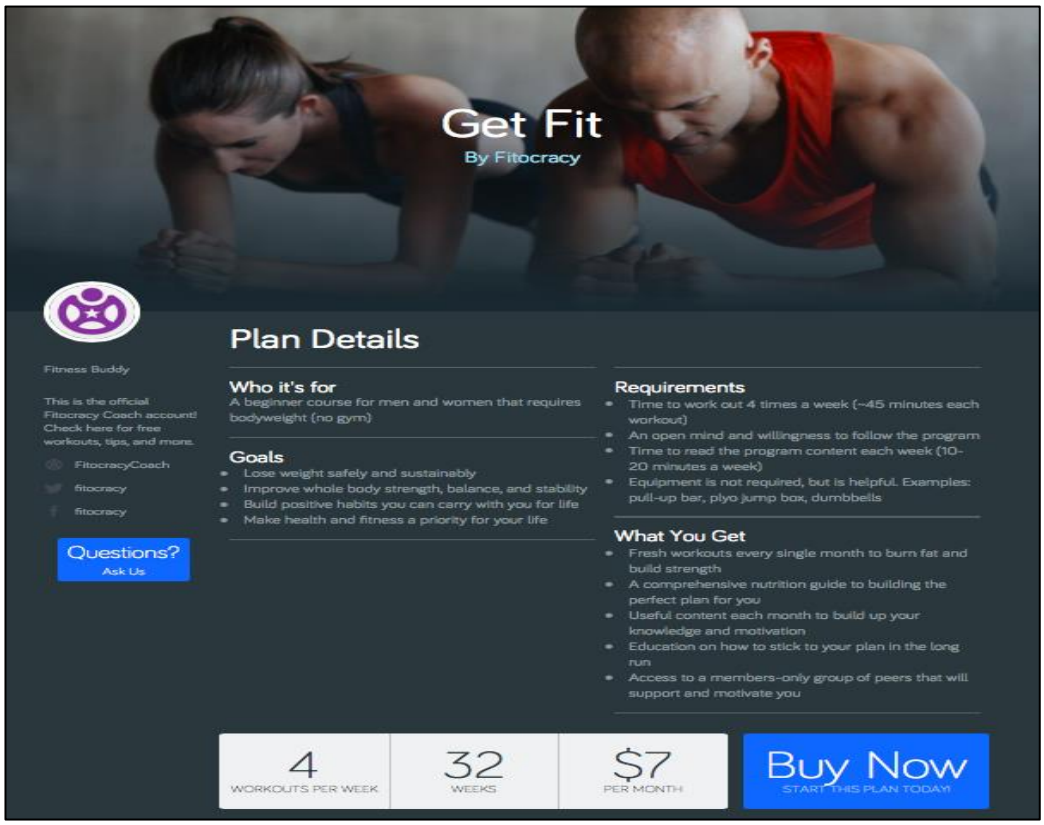


Figure 5.3: Get Fit for $7 a Month on Fitocracy

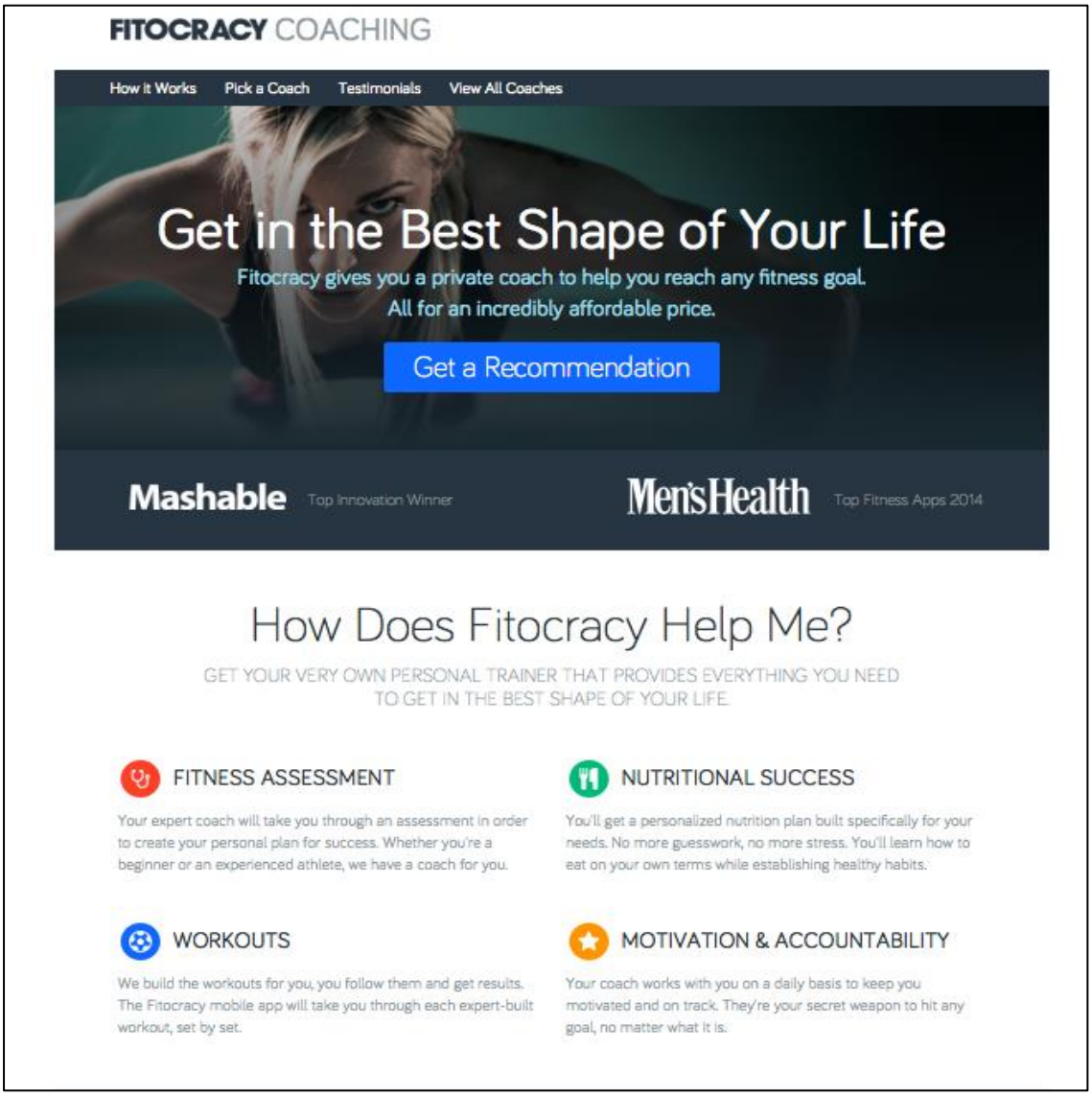


Figure 5.4: Personalised Coaching Through Fitocracy

Figure 5.5: Become a Fitocracy Hero

5.3 Discussion and Conclusions

The comprehensive process evaluation has provided greater insight into the usefulness and practicality of replicating the newly designed theory-based methodological approach for designing or selecting gamefully designed interventions. The findings showcase how the selected gamefully designed intervention application (Fitocracy), employing the identified SMAs (Chapter 3), influenced the proximal mediators: motivational regulation, need satisfaction and behaviour change. The semi-structured interviews, in particular, provided an in-depth view into the more critical layers of how and why the quantitative results were observed, exposing the challenging aspects of integrating the disciplines of gameful design, motivation and physical activity. The process evaluation conducted and presented here adds valuable insight regarding context and mechanisms of impact related to the chosen gamefully designed physical activity application for the example case intervention connected to the theory-based development.

The selected intervention application, Fitocracy, tested in *Study 2,* showed no significant effects. There are at least four different possible explanations for this finding: (1) issues with the study design; (2) issues with the user experience of the intervention design; (3) particular contextual factors and constraints; and (4) the small sample size. Fitocracy lacked impact on participants' motivation for physical activity. Some participants struggled with technological competence, understanding and utilising Fitocracy, which presented challenges and led to lack of interest, non-use or very little use of the application. The lack of face-to-face guidance, connection and interaction with real people was an emerging theme among the interviewees, although the feedback regarding the research appointments and research staff was overwhelmingly positive, dominated by statements of praise.

Even though Fitocracy offers a variety of situated motivational affordances, it appears that the most challenging barrier laid in the initial adoption of the application. Those individuals who chose to use it more than once collectively reported the tracking feature as being the most integral part of the application, while showing little interest in the other features available. Further, interviewees clearly expressed a desire to have had face-to-face guidance or interaction related to the physical activity aspects of the intervention. Fitocracy reminded several of yet another social media platform lacking privacy and being impersonal. As SDT asserts (Deci and Ryan, 2000), relatedness is a basic psychological need playing an integral part for motivation to be fostered. Although relatedness can manifest itself in various domains, the interviewees in this study were looking for the human face-to-face interaction rather than the possibility for technological connection with strangers. More than just human interaction, interviewees expressed a desire for social support in this realm, which has been identified as one of the most significant determinants for physical activity engagement (Booth et al., 2000; Wendel-Vos et al., 2007).

The fact that Fitocracy required participants to manually track physical activity and log into the application in order to engage with it seems to have presented another obstacle, with interviewees citing that this just added another thing to do to their already long list of life responsibilities. Although the interview analysis provided these findings, the question of how ready these individuals were to actually engage in physical activity behaviour change emerges. This particular subject was not integrated in the protocol at any point and so cannot be answered within the scope of this study. But what can be said is that Fitocracy did not manage to instil physical activity motivation in people who were motivated enough

to enrol in the research study indicating some level of readiness to change physical activity behaviour. In addition to these possible explanations, however, emerges the item of understanding of expectations from the participant. During recruitment, participants received basic information about the study, but were not informed explicitly about the intervention application, what options existed within the application, how much time it would take to engage with and what application would be utilised. It is possible that this also impacted participants' readiness factor.

Further, there does not seem to be a correlation between Fitocracy usage (based on physical activity tracked), enjoyment of Fitocracy, dislike of Fitocracy and increase in physical activity levels. Every participant had individual, unique circumstances, and was influenced by particular motivators and drivers, obstacles and barriers. For some, Fitocracy seemed to be a welcome feature helping in the process of becoming more physically active, but for the majority, it was not.

The participants' experience of the overall study implementation was overwhelmingly positive. The processes related to research appointments, location and research staff were well received and had a positive impact on research participants, making them feel comfortable being in the study. The interviews revealed that for some, the accelerometer itself had an impact on motivation for physical activity and in turn physical activity levels. It acted as an accountability mechanism for some.

It is unclear whether and how the questionnaires (BREQ-2 and IMI) impacted participants' motivation for physical activity throughout the study. Participants reported that the layout of the questionnaire on the computer screen was not very clear, reiterating that questions seemed to repeat themselves over and over. The questions of the BREQ-2 and IMI all dealt with self-reflective statements related to physical activity, so it is possible that for some participants, these questionnaires acted as a mechanism of impact.

Further, the process evaluation uncovered the complexity of measuring motivation in relation to different constructs, such as the BREQ-2, IMI and PENS. BREQ-2 and IMI measure levels of motivation for physical activity (BREQ-2 was modified for this purpose) and PENS was utilised to assess the selected intervention application, Fitocracy. Each measure provided important information about a particular construct (Section 4.4.3); however, it is vital to realise that motivation for engagement with Fitocracy may not automatically lead to motivation for physical activity as these are independent variables. Nevertheless, employing these measurement tools was vital to create a baseline of understanding of independent motivational constructs of the participants. This, again, is another example of showcasing the importance of qualitative assessment to investigate the possible connections, disconnections, dependent and independent variables contributing to the results observed. Carefulness in interpretation of these findings is vital to avoid drawing false conclusions of connections between the different measuring tools (Section 4.4.3; Section 5.2.3.3).

The purpose of interviews was to evaluate participant experience and mechanisms of impact on motivation for physical activity in order to determine whether conducting a fully randomised controlled trial in the future would be feasible. Based on the interview analysis, it appears that the issue of initial adoption of the intervention application would have to be remedied more specifically to be able to measure actual impact of a gameful application like Fitocracy. This may entail a modification of the initial introduction to the

intervention application and further in-person support sessions to ensure a higher level of competence when interacting with the technological application.

The newly created *Taxonomy of SMAs for Gameful Design* marks the key component of this three-phase research study design, building the foundation for the selection and design of the example case intervention (Chapter 4). Fitocracy was carefully selected based on the taxonomy because it exemplified the employment of 13 of the 14 identified SMAs (see Chapter 3). The detailed process evaluation of the different contextual factors and mechanism of impact provides a footprint for future research in developing a detailed validation protocol for the *Taxonomy of SMAs for Gameful Design.* This could occur via experiments and Factor Analyses. This research study drew on previous existing research to establish new and clear connections between SMAs, motivation and behavioural constructs via the new taxonomy tool proposing a new framework for intervention application, which was done here via the example case intervention (Chapter 4). This new tool strengthened this research by filling one of the key identified gaps within gameful design research, namely applying theory-informed, appropriately developed methodological practice to an actual intervention protocol. Based on the process evaluation, future further work should focus on fully validating this newly created taxonomy, including evaluating each individual SMA within different contexts and for different behaviours.

To inform other researchers on how gamefully designed interventions can be systematically developed and tested, it is vital to identify the strengths and weaknesses of the approach taken in this thesis. Systematic evaluation strategies will differ depending on the aims and objectives for a given intervention protocol. The present evaluation focused on how the developed theoretical framework informs the development of a gamefully designed physical activity intervention. Thus, the approach to defining the strengths and weaknesses originates from this basis.

As showcased in the review of existing literature (Chapter 2), there are a few very important identified gaps within current research that have been addressed by this thesis' approach. Firstly, a strength of the approach of this research is to have grounded it in evidence-based theoretical frameworks, such as SDT and BCTs. Secondly, a specifically applicable methodological approach was implemented utilising the evidence-based IM framework, which built the overarching scaffolding for the entire three-phase research study. It systematically guided each of the steps of the process. Further, a novel theory-grounded taxonomy was created integrating gameful design, motivational and behavioural outcomes, forming a more robust approach than currently exists within research. This process entailed a thorough, in-depth evaluation of existing knowledge, research and methodologies and integrating different disciplines together to create a more comprehensive strategy informing the selection of an intervention application for a case example. Further, a clearly articulated criteria checklist for the selection of fitting gamefully designed physical activity intervention applications was developed. Although established specifically for the context of this study, it is a blueprint for the adaptation to other related types of interventions.

Specifically regarding the case example intervention design, current research gaps were also addressed, thus manifesting themselves as strengths for this study's approach. One key strategy that was utilised is the usage of objective measures for physical activity behaviour yielding more accurate results as opposed to self-report measures. Although the estimated sample size for *Study 2* was not achieved, the number of participants exceeded the number in many other

previous protocols aiming to detect similar outcomes (Chapter 2). A randomised control trial was implemented with a control and intervention group for more rigorous research methods. Further, *Study 2* used validated measurement tools (BREQ-2, IMI, PENS) related to assessing motivation for physical activity and gameful design and overall a mixed method approach was implemented to investigate deeper, underlying issues and concepts not evident via quantitative data.

Although the evidence-based IM framework was applied, step one of IM was only undertaken at a theoretical level. Based on the context of this study and resources available, it was not feasible to engage with the stakeholders prior to intervention implementation to obtain specific feedback and guidance to forming the especially designed intervention protocol. However, even though it would have been more ideal to have this step executed at a more thorough level, the way it was done represents a more real-world scenario rather than a laboratory condition. In this case, this was particularly relevant because the nature of gamefully designed physical activity applications available are typically distributed via commercial venues at a mass-market level and not at small, individualised levels. Thus, more versatility is necessary for a higher success rate, which was specifically discussed and applied during the creation of the new *Taxonomy of SMAs for Gameful Design*.

If motivational and behavioural outcomes are the goal of any gamefully designed intervention protocol, as they were in this study, then one of the key challenges will always be how to interpret the findings related to motivation as the integrated areas overlap and motivation is highly individualised. Although questionnaires, such as the BREQ-2, IMI and PENS in this study, provide quantitative data about motivation for particular behaviours, they do not provide the insight into the possible connections between constructs. Therefore, it is essential to employ qualitative assessment methods to explore the deeper underlying issues of how and why motivation occurs for different people at different points and if motivation to engage with the gamefully designed intervention actually impacted motivation for the target behaviour (physical activity) or if motivation to engage with the activity does not correlate with motivation for physical activity. This highlights and underlines the limitations and strengths of this study at the same time in relation to this particular issue.

Another limitation in this study is that more concrete questions could have been added to the semi-structured interviews to investigate the different motivational factors specifically pertaining to physical activity and to the gamefully designed application. In retrospect, more in-depth structured questions related specifically to motivational elements would have been helpful and should be included in future research for a more thorough evaluation of the effectiveness of a gamefully designed intervention.

Although this was not the aim of this study, a detailed assessment of each individual SMA would have added valuable information within the context of the selected application and also could have been part of a validation process of the newly designed taxonomy. Potential researchers should entertain this concept when systematically evaluating a gamefully designed intervention aimed at impacting motivation and/or behavioural outcomes to determine the efficacy of individual variables.

The identified strengths and weaknesses can serve as a clear guide for future researchers as it pertains to how gamefully designed interventions can be

systematically evaluated. For easier view and future application, Table 5.16 proposes a systematic evaluation checklist based on the findings of this study; thus, it is a suggestion, but not limited to what is presented.

Table 5.16: Systematic Evaluation for Gamefully Designed Interventions Checklist

Evaluation Question	Yes/No
Have evidence-based theories been utilised appropriately to frame the gamefully designed intervention development and execution?	
Have evidence-based methodological frameworks been utilised to guide the research and intervention approach for the gameful design context?	
Has the advanced understanding of SMAs in the context of gameful design been considered in the design of the intervention?	
Does the evaluation process of a gamefully designed intervention include objective evidence-based measures (e.g. accelerometers for physical activity interventions)?	
Does the research approach for a gamefully designed intervention include a mixed methods evaluation?	
Are the selected measures validated tools?	
Does the evaluation approach take into consideration assessment of individual gamefully designed variables?	

CHAPTER 6: DISCUSSION

6.1 Introduction

Physical inactivity has become a major health concern worldwide, leading to large numbers of preventable cases of chronic disease and early death (WHO, 2010). In the U.S., nearly 80% of adults do not meet recommended physical activity guidelines (CDC, 2010a). Increasing motivation has been shown to be one important pathway to tackling low levels of physical activity (Teixeira et al., 2012). One promising novel strategy to increase motivation is gameful design (Sailer et al., 2013), particularly when delivered through web and mobile interfaces, which now reach the majority of populations worldwide (Seaborn & Fels, 2015).

Reviewing the literature revealed three major research gaps within gamefully designed interventions for physical activity: first, there is little rigorous, research-based, theoretically grounded methodology for designing and/or choosing gamefully designed interventions, particularly for health behaviour changes like increasing physical activity (Kato, 2012); second, and connected to that, there is a lack of theory-based guidance about what particular game design elements or motivational affordances fit what particular use cases; third, we are lacking rigorous, longitudinal empirical studies on the effects of gameful design in health, particularly on actual behavioural and health outcomes (Gotsis et al., 2013; Thorsteinsen, Vittersø & Svendsen, 2014).

This thesis consisted of three studies that answer to these gaps. Grounded in SDT (Deci & Ryan, 1985), the *Theoretical Framework Design Study* (*Study 1*) developed a strategic theory-grounded methodology, using the IM approach (Bartholomew et al., 2016) for choosing and/or designing gamefully designed interventions. Possible health behaviour change techniques and SDT constructs were matched against the newly developed *Taxonomy of Situated Motivational Affordances for Gameful Design.* This study thus presents an interdisciplinary approach to designing an evidence-based, theoretically grounded methodology for gamefully designed interventions for motivating physical activity and physical activity behaviour. This comprehensive work presents a novel approach contributing to current research a new theoretically based methodological framework to fill important existing gaps. Further, the work showcased in this thesis adds valuable evidence-based knowledge and understanding to provide future researchers new baselines and foundations upon which to build more rigorous intervention research approaches currently lacking within this interdisciplinary field. The *Intervention Implementation Example Case Study* (*Study 2*) applied and tested the carefully selected application (Fitocracy) over a six-month period. The *Process Evaluation Study (Study 3)* investigated the usefulness, effectiveness and practicality of *Study 1* and *Study 2*, and determined implications for future replication, validation and development for researchers.

6.2 Key Findings and Discussion

6.2.1 Theory-Based Guidance on Gamefully Designed Intervention Development

The main aim of this study was to determine how the systematic design of a theoretical framework would inform the development of gamefully designed physical activity interventions. The IM approach was effectively applied to provide theoretical guidance for the development of a framework to aid in the selection process of appropriate gamefully designed interventions. Helf and Hlavacs (2016) specifically recommended the IM approach for gamefully designed health

interventions, but there was no prior work specifying how to apply IM concretely in this case. *Study 1* resulted in two main key developments. First, a review of SDT, gameful design and health behaviour change techniques (BCTs) led to the creation of a new *Taxonomy of Situated Motivational Affordances for Gameful Design*. Helf and Hlavacs (2016) suggest that health interventions be based on BCTs and health goals. Cowan et al. (2013) also suggest that BCTs should be the medium through which possible connections to effective applications could be designed. The taxonomy developed here arguably delivers on this need by identifying individual motivational affordances with matching psychological and behavioural constructs. It presents a novel contribution to the field of study of gameful design in relation to health behaviours that informs future research and provides a solid foundation on which to build. Second, an inclusion criteria checklist was developed to aid in the selection of a gamefully designed physical activity application for the purpose of the pilot intervention (*Study 2*). Although specifically designed for this research study, this checklist has the potential to be adapted to other health behaviour contexts besides physical activity behaviour and could provide a central and dynamic pathway to the selection of intervention applications (Helf & Hlavacs, 2016).

The selection process of a suitable intervention application revealed two additional findings: (1) there is a dearth of research evaluating the effectiveness of current commercially available gamefully designed physical activity applications (cf. Payne, Moxley & MacDonald, 2015), and (2) only one current commercial application (Fitocracy) fit the criteria checklist developed for this study; in other words, most existing commercial applications lack the integration of evidence-based knowledge related to motivation and health behaviour change. As technical applications have become a primary mode of health-related interventions (Riley et al., 2011), this lack of the integration of research in consumer applications is all too common (Boulos et al., 2014), but nevertheless problematic. This lack can be explained by the fact that health application developers are in fierce competition and measure success by revenue gains rather than by actual effectiveness (Lister et al., 2013). New technological trends might be adopted for their marketing value rather than for their proven effectiveness. Our survey indicates that this problematic state of affairs also holds for current commercial gamified interventions.

6.2.2 Effectiveness of Gameful Design

Another aim of this study was to determine whether a theory-driven gamefully designed intervention impacts motivation for physical activity as well as actual physical activity levels among sedentary adults. *Study 2*, a case example study, found no significant changes in either MVPA or intrinsic motivation; however, statistically significant changes were detected in internalised motivation (identified regulation) at the six-week data collection point. The findings related to MVPA are somewhat contrary to existing research: in a 13-week field experiment, Gotsis et al. (2013) found an increase in self-reported exercise frequency. In a randomised controlled trial, Zuckerman and Gal-Oz (2014) observed increased walking times in various groups. During another randomised controlled trial over a three-month period, Thorsteinsen, Vittersø and Svendsen (2014) observed a significant increase in physical activity among the intervention group at two time points (week five and nine).

One possible explanation for the findings of this thesis is that contrary to previous studies, it addressed all major identified methodological shortcomings, with the use of: (1) behavioural data collection (accelerometers) instead of self-reporting measures; (2) integration of theory-based frameworks; (3) a longitudinal data

collection with multiple data collection points; (4) a larger sample (although as noted in Chapter 4, even the sample size in this research study was too small to show significant findings); (5) rigorous mixed-research methods; and (6) an interdisciplinary approach. Prior studies generally face the main limitations of employing only self-reported exercise data (Gotsis et al., 2013; Thorsteinsen, Vittersø & Svendsen, 2014), or utilising short study time frames (e.g. two weeks) (Zuckerman and Gal-Oz, 2014).

Another possible explanation for the lack of change in MVPA is the rather high levels of MVPA during the baseline data collection for the control and intervention groups, technically placing the majority above the sedentary behaviour level. This left very little room for increase in physical activity for the remainder of the study. It also puts a question mark behind the effectiveness of the IPAQ used to screen participants for physical activity levels prior to enrolment, although this questionnaire was found to show acceptable, reliable and valid measurement properties in testing (Craig, Marshall & Sjöström, 2003). All participants in this study qualified as being sedentary based on the IPAQ, yet during baseline data collection, their MVPA levels were much higher. Possible explanations for this phenomenon include: (1) participants wanted to participate in the study, thus did not provide accurate self-reported data during screening; (2) the IPAQ is ineffective; (3) participants were anxious and ready to go when the study commenced, and put in much more effort during the baseline data collection week; (4) participants obtained motivation by wearing the blinded accelerometers and by attending the initial assessment appointment, which provided a greater self-awareness of the current state of their physical activity levels; and (5) the baseline data collection week did not represent the participants' usual physical activity levels due to other unusual circumstances. It is also possible that initial higher MVPA levels resulted from a combination of all of those factors.

A third possible explanation is that prior work on gamefully designed physical activity interventions did not make prior sedentarism or physical inactivity an inclusion criterion. Thorsteinsen, Vittersø and Svendsen (2014) simply required participants to have access to the Internet, own a mobile phone and be in good health. Although participants were questioned regarding their readiness to change and their physical activity levels, no specific inclusion requirements regarding these aspects were defined. The same holds for Zuckerman and Gal-Oz (2014): in that study physical activity levels were asked about prior to enrolment, but were not made as part of the inclusion criteria. This is a significant difference in participant selection, as motivation for physical activity and physical activity levels differs among individuals who are usually sedentary and those that may already engage in physical activity and are perhaps looking to continue to increase frequency and intensity. In short, observed levels of MVPA change might have been lower in this study because its screening method for self-reported PA resulted in the inclusion of a sample that was harder to change. So, although screening for physically inactive people must continue being a priority, and these people should be the target population, better screening tools need to be implemented.

The case example intervention in this study showed an increase in internalised motivation for physical activity at the six-week data collection point only. Identified regulation displayed significant results among the intervention group at that time point. Identified regulation is a form of autonomous internalised motivation demonstrating conscious value for a particular thing or behaviour (Deci & Ryan, 2000); however, it is not fully self-determined, thus not intrinsic. It means that something is important or beneficial, but not necessarily enjoyable in itself.

Increased levels of identified regulation indicate a change in value and a shift on the Self-Determination Continuum towards intrinsic motivation (Deci & Ryan, 2000). Teixeira et al. (2012) note that identified regulation predicts initial and short-term adoption of physical activity behaviour more strongly than intrinsic motivation, which in turn is a stronger predictor of long-term adherence to exercise. Daley and Duda (2006) also observed that identified regulation shows a stronger effect than intrinsic motivation in the short term. In this study, significant results were observed only during the six-week intervention period and not again at any of the other collection points throughout the six months. Thus, this means that participants in the intervention group valued physical activity; however, it is unclear if increased identified regulation was linked to the gamefully designed application or to other personal beneficial reasons.

The results also showed a positive correlation between intrinsic regulation and MVPA and a negative association between external regulation and MVPA, validating theoretical concepts of SDT (Deci & Ryan, 2000). This observation is in line with previous research (Teixeira et al., 2012). Perceived competence, one of the six subscales of the IMI, had a significant association with physical activity levels, again confirming previously discovered findings in line with SDT (Deci & Ryan, 2000; Teixeira et al., 2012).

Based on the results of the case example intervention, the sample size for a possible future definitive randomised controlled trial was estimated. Due to the small sample size of this pilot case example, it is important to note that this recalculation is merely an estimate, not an absolute. The effect size of this case example study was a six-minute difference between the intervention and control groups, which would lead to a possible required future sample size of 1,689 subjects (Section 4.4.6).

In summary, *Study 2* found no significant effects of gameful design on physical activity levels, no marginal effects on intrinsic motivation, but increased identified regulation at six weeks. Possible explanations for these contradicting results to prior research are a more rigorous applied methodology and ecologically valid sample, unusually high initial MVPA levels or a combination thereof.

6.2.3 Usefulness, Effectiveness and Feasibility

A third aim of this study was to determine the usefulness, effectiveness and feasibility of the newly designed methodological approach and connected to that, the example case pilot intervention. This evaluation resulted in several key findings: (1) development of novel theory-based methodological contribution of the newly designed *Taxonomy of SMAs for Gameful Design* useful as a strong footprint for future research, linking motivational and behavioural constructs to SMAs; (2) creation of theory- and evidence-based selection criteria checklist provided clear guidance on careful selection of gamefully designed physical activity application (Fitocracy) for an example case pilot intervention; (3) a low adoption rate of the selected intervention application Fitocracy among the intervention group; (4) despite a lack of impact on MVPA and on specifically intrinsic motivation for physical activity, increased identified regulation levels at six weeks of the example case intervention showed increased internalised motivation for physical activity within the intervention group; (5) a lower overall attrition rate (11.7%) within the pilot intervention than originally estimated (30%); (6) an overall positive response from participants in the pilot intervention regarding the entire research implementation process, including assessment appointment procedures, scheduling procedures, research staff professionalism and friendliness; and (7)

the discovery of how the complex nature of human motivation impacted how each individual within the intervention group, each at a different point on their journey of physical activity behaviour change, was driven and motivated by different factors within and outside of the selected intervention application.

Logging data revealed that a significant proportion of study participants did not use the application (Fitocracy) at all or used it only once. One obvious reason for the lack of an effect on physical activity and motivation in this pilot study is that people did not adopt the gamefully designed application itself. In gameful design industry literature, there is a common argument that a major hurdle to health behaviour change is a lack of initial motivation to exercise, which can be overcome by gameful design to help people over an "initial hump" until experiences of success and, thus internalised motivation, kick in (Beerda, 2015). The collected data suggests that this theory already presupposes the overcoming of an even prior barrier: the willingness to adopt the gamefully designed application itself. It also suggests that the gamefully designed application we tested did not successfully motivate people to continue using it. Instead, interviews indicate that people found little value in the game elements themselves: what was perceived as valuable was chiefly the basic tracking functionality of the application. In fact, interviews indicate that several people found Fitocracy demotivating in the way it added tedium and complexity to their lives. A possible counter-argument is that the app itself might not be well-designed; however, the app has over two million registered users and a 4.5 out of 5 star rating on the iTunes store, based on 1,500+ ratings (July 12, 2016), suggesting that it represents a generally well-designed, middle- if not top-of-the-market representative of gamified fitness applications.

This suggests that gameful design may be an effective motivational strategy for people who already bring in sufficient motivation to become physically active on their own (and who adopt an application that supports this personal goal), but not for individuals who want to become more physically active (all the participants in our study voluntarily signed up for an intervention to become more physically active), but are not sufficiently motivated to engage in physical activity and in support activities like self-tracking on their own. This puts a serious question mark behind the ecological, "in-the-wild" utility of gameful design.

Considering the future feasibility of a fully randomised controlled trial, a larger sample size is needed resulting in higher costs associated with objective measurement tools, such as accelerometers. These devices presented the most costly element of the pilot study. On the contrary, the selected intervention application, Fitocracy, is free of charge, making it very feasible to adopt for a larger sample size.

The results also revealed the important issue of the readiness factor to change behaviour (DiClemente & Prochaska, 1998). This aspect was not included in the screening or enrolment process of this research study and may have impacted low initial adoption and adherence rates. However, although this measure was not employed, participants in this study did take the initiative to enrol in the study, demonstrating a form of action toward change. Further, even if this measure had been included in the screening process, it would have had to be determined how the results would impact the research protocol and whether additional requirements would have had to be integrated into the inclusion criteria list (e.g., only those individuals with a certain readiness-to-change level could participate). In addition, an initial screening of participants' motivators for physical activity may have been helpful for the introductory session of Fitocracy in order to establish

meaningful connections to situated motivational affordances within the application that resonated with the participants.

6.3 Strengths and Limitations

The key development of this research study is the rigorous methodological development, including the *Taxonomy of Situated Motivational Affordances for Gameful Design,* which guided and informed the selection of an appropriate intervention application to be tested in an example case pilot intervention. This novel framework makes an important contribution to the emerging field of physical activity behaviour and gameful design, rooted in evidence-based models such as BCTs and SDT. The IM approach, recommended specifically for gamefully designed health interventions (Helf & Hlavacs, 2016), guided the entire research process, providing a sound methodological, sequential, yet iteratively applicable approach that incorporated the newly developed taxonomy.

Closely tied to the aforementioned primary strengths of this study, the engagement in interdisciplinary work is a significant advancement in this field. Subject areas of expertise represented here included: (1) health behaviour change; (2) human motivation; (3) physical activity behaviour; and (4) gameful design. This integrated approach to research allowed for multiple angles of understanding improving overall quality. Lister et al. (2014) conclude that to effectively influence health behaviour change through gamefully designed approaches a comprehensive integration of subject areas and experts is necessary. Integrated user-centred frameworks, multidisciplinary in nature, may provide a solution to find more effective pathways to positively impact health behaviour (e.g. physical activity) (Helf and Hlavacs, 2016), which this study offers.

Particularly in contrast with existing work (Gotsis et al., 2013; Thorsteinsen, Vittersø & Svendsen 2014; Zuckerman and Gal-Oz, 2014), this study addresses the majority of methodological shortcomings identified for gamified health interventions. First, a mixed-methods approach was employed, blending quantitative and qualitative measures to obtain a more complete and accurate picture of the phenomena under investigation (cf. Seaborn & Fels, 2015). Although not novel within research in general, mixed-method research has not been widely applied to gamefully designed physical activity interventions. Second, this study collected objective behavioural data via accelerometers as opposed to self-reported physical activity information. Findings in previous research suggest that self-reported physical activity levels do not accurately represent actual activity levels, often being over- or even under-reported; thus, valid objective measures are needed (Prince et al., 2008).

A first limitation for this overarching study is the lack of stakeholder engagement as part of the first step of IM, which entails the needs assessment of the context and the population selected for the change intervention. Consultation with stakeholders of the targeted recruitment population in this study could have allowed the gathering of useful data and ideas specific to the intervention application selection. This could have increased the credibility of the final choice in addition to the evidence-based research utilised to develop that criteria. Prior stakeholder involvement could have increased the buy-in of and engagement with the selected intervention application (Fitocracy). Further, it could have elicited greater support and increased participation, particularly among the intervention group, which showcased very low rates of adoption.

Instead of stakeholder engagement, a thorough assessment of the health problem (physical inactivity behaviour) and its effects on related conditions was conducted

via review of research evidence, providing a scientific description of the situation, context and population chosen for investigation. Further, the theoretical study of issues related to human motivation, behaviour change aspects and gameful design issues were reviewed and studied in-depth. In the context of this particular research study, engaging stakeholders posed a logistical and financial challenge and also would have potentially compromised the authentic real-world scenario of commercialised gamefully designed physical activity applications; however, on the other hand, stakeholder engagement could have added effectively to a greater understanding of the targeted recruitment group directly. The qualitative interviews post-intervention revealed the complexity of individualised context and preferences in relation to the selected application, which provides some after-effect insight to the notion that motivation is a very personalised contextualised process and this particular understanding was derived from the theoretical study, which led to the intervention application selection.

A secondary limitation for this study is that the newly created Taxonomy of SMAs for Gameful Design was hereby not yet validated; however, this was outside of the scope of this research. The process evaluation (Chapter 5) provides useful and practical information regarding the implemented processes, informing future researchers. Alongside this, a detailed evaluation of the individual SMAs presented in the newly created taxonomy would provide vital information for future usage and implementation thereof.

Another limitation for *Study 2* is the sample size of the case example. The recruitment process presented a significant challenge. Although a rather large geographical area was targeted (IE of Southern California), the desired initial calculated sample size (124) was not achieved after nine months of focused recruitment efforts. However, this was a pilot trial, which aimed to test the feasibility and success of recruitment methods for a future fully randomised controlled trial; thus, a smaller sample size for this purpose is acceptable.

It was too expensive and not feasible to design a specialised technological gamefully designed application for *Study 2*; thus, an existing commercial application was selected. Using a commercial application presented limitations of customisation specific to the purpose of this intervention, which refers to the choice of SMAs expressed in gamified features within the system. Further, using a commercial application presented challenges regarding accessing participants' data in an effective way. Thus, only basic data was possible to be retrieved without any access to the back-end data of the system. Against this stand the advantages of utilising an available commercial application: cost-effectiveness and accessibility for a large number of participants.

6.4 Future Research Directions

Future research should apply and validate the newly created *Taxonomy of SMAs for Gameful Design* within the context of physical activity behaviour. Apart from developing a generally useful tool for researchers, validating and refining the newly developed taxonomy would enable practitioners to determine which gamefully designed applications and interventions have a greater chance for success. Particularly, exploration of users' orientation toward gamefully designed web- and mobile-based applications might be beneficial to determine features and elements that may be largely more motivating than others. This could be done via experiments and Factor Analyses.

Future research should also assess the impact of gamefully designed technological applications on people who already voluntarily engage with a

particular physical activity application, as compared to inactive people, in order to better measure effectiveness. This study revealed that the initial adoption of the intervention proved to be a significant barrier, preventing more detailed observations of impact of the actual application, although some of this was captured through the follow-up interviews. Thus, in addition, future research should explore mechanisms to assist people to overcome the barrier of initial adoption of a gamified physical activity intervention application prior to designing pathways of impact of the actual gamified physical activity application. One way to prepare potential participants is to clarify in the participant information sheet that an active part of the programme is the usage of an application like Fitocracy.

Further, the assessment of participants' readiness to change physical activity behaviour may be useful during the screening process or baseline data assessment, as that could significantly impact engagement with the intervention application and actual physical activity behaviour. Such a process may necessitate the employment of modified, more individualised processes that prompt greater initial engagement in order to assess the actual impact of gameful design on motivational levels and on physical activity levels. Future research should consider incorporating careful steps to ensure increased individualised opportunities for initial engagement.

Future research studies should continue to employ objective data collection via accelerometers or other similar reliable devices instead of or in addition to self-reported data. Specifically, it is important to find devices that are functional, accurate and dependable, particularly if utilised during a large research trial.

It is also recommended to continue to engage in interdisciplinary teamwork, merging areas of expertise in the fields of motivation, physical activity behaviour and gameful design. Additionally, future work should entertain the possibility of finding ways to merge the commercial business industry with research and educational experts, in order to maximise the possibilities of impact on a grander scale.

6.5 Conclusions

The combined findings of the three studies stress that there is significant need and room for more theory-based research and intervention designs to better understand potential pathways to impact and thus increase the likelihood of achieving real-world impact. Gamefully designed applications grounded in theories such as SDT, BCTs and the newly developed *Taxonomy of Situated Motivational Affordances for Gameful Design*, have the potential to be effective in impacting motivation for physical activity and physical activity levels. They also stress the value and necessity of mixed-methods approaches, theory grounding, longitudinal designs, and objective behavioural measures to obtain valid and useful findings for identifying and refining effective physical activity interventions, through gameful design and otherwise. Finally, the results stress the need for ecologically valid studies: the qualitative data suggests that a major reason for the ineffectiveness of the employed application was the lack of initial adoption—a finding hard to obtain in any laboratory setting.

REFERENCES

Abraham, C. and Michie, S., 2008. A taxonomy of behavior change techniques used in interventions. *Health Psychology*, 27(3), pp.379–387.

Ahmed, N.U., Smith, G.L., Flores, A.M., Pamies, R.J., Mason, H.C., Woods, K.F. and Stain, S.C., 2005. Racial/ethnic disparity and predictors of leisure-time physical activity among US men. *Ethnicity & Disease*, 15, pp.40–52.

Ahola, R., Pyky, R., Jämsä, T., Mäntysaari, M., Kosimäki, H., Ikäheimo, T.M., Huotari, M.L., Röning, J., Heikkinen, H.I. and Korpelainen, R., 2013. Gamified physical activation of young men—a multidisciplinary population-based randomized controlled trial (MOPO study). *BMC Public Health* [Online], 13(32). Available from: *http://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-13-32* [Accessed 18/06/2013].

Ajzen, I., 1985. From intentions to actions: A theory of planned behavior. In: J. Kuhl & J. Beckmann, eds. *Action control: From cognition to behavior*. Berlin, Heidelberg, New York: Springer-Verlag Berlin Heidelberg, pp.11–39.

Ammendolia, C., Côté, P., Cancelliere, C., Cassidy, J.D., Hartvigsen, J., Boyle, E., Soklaridis, S., Stern, P. and Amick III, B., 2016. Healthy and productive workers: using intervention mapping to design a workplace health promotion and wellness program to improve presenteeism. *BMC Public Health* [Online], 16(1190). Available from: *https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-016-3843-x* [Accessed 28/12/2016].

Anderson, A., Huttenlocher, D., Kleinberg, J. and Leskovec, J., 2013. Steering user behavior with badges. *Proceedings of the 22nd international conference on World Wide Web*, 13–17 May 2013 Rio de Janeiro, Brazil. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?doid=2488388.2488398* [Accessed 11/01/2017].

Antin, J. and Churchill, E.F., 2011. Badges in social media: a social psychological perspective. *Proceedings of CHI 2011 Gamification Workshop*, 7–12 May 2011 Vancouver, BC, Canada. New York: ACM [Online]. Available from: *http://gamification-research.org/wp-content/uploads/2011/04/03-Antin-Churchill.pdf* [Accessed 18/07/2013].

Aparicio, A.F., Vela, F.L.G., Sánchez, J.L.G. and Montes, J.L.I, 2012. Analysis and application of gamification. *Proceedings of the 13th International Conference on Interacción Persona-Ordenador*, 3–5 October 2012 Elche, Spain. New York: ACM [Online], Article No. 17. Available from: *http://dl.acm.org/citation.cfm?id=2379653&dl=ACM&coll=DL&CFID=654028171&CFTOKEN=56527423* [Accessed 04/10/2013].

Arnab, S. and Clarke, S., 2015. Towards a trans-disciplinary methodology for a game-based intervention development process. *British Journal of Educational Technology* [Online]. Available from: *http://onlinelibrary.wiley.com/doi/10.1111/bjet.12377/full* [Accessed 28/12/2016].

Bandura, A., 1977. Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, 84(2), pp.191–215.

Baranowski, T., Buday, R., Thompson, D.I. and Baranoswki, J., 2008. Playing for real: Video games and stories for health-related behavior change. *American Journal of Preventive Medicine*, 34(1), pp.74–82.

Baranowski, T., Buday, R., Thompson, D., Lyons, E.J., Lu, A.S. and Baranowski, J., 2013. Developing games for health behavior change: Getting started. *Games for Health Journal*, 2(4), pp.183–190.

Bartholomew, L.K., Parcel, G.S., Kok, G., Gottlieb, N.H. and Fernández, M., 2011. *Planning health promotion programs: An intervention mapping approach.* 3rd ed. San Francisco, CA: Jossey-Bass.

Bartholomew, L.K., Markham, C.M., Ruiter, R.A.C., Fernàndez, M.E., Kok, G. and Parcel, G.S., 2016. *Planning health promotion programs: An intervention mapping approach*. 4th ed. San Francisco, CA: Jossey-Bass.

Bassett, D.R., 2012. Device-based monitoring in physical activity and public health research. *Physiological Measurement*, 33(11), pp.1769–1783.

Baumeister, R. F. & Leary, M. R., 1995. The need to belong: Desire for interpersonal attachments as a fundamental human motivation, *Psychological Bulletin*, 117, pp. 497-529.

Beerda, J., 2015. *How to use rewards in Gamification without killing motivation* [Online]. Hong Kong: Octalysis Group. Available from: http://blog.octalysisgroup.com/?p=324 [Accessed 28/07/16].

Berengueres, J., Alsuwairi, F., Zaki, N. and Ng, T., 2013. Gamification of a recycle bin with emoticons. In: H. Kuzuika, V. Evers, M. Imai and J, Forlizzi, eds., *Proceedings of the 8th ACM/IEEE International Conference on Human-Robot Interaction*, 3–6 March 2013 Tokyo, Japan. New Jersey: IEEE [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2447578&dl=ACM&coll=DL&CFID=893154911&CFTOKEN=89238578* [Accessed 13/01/2017].

Booth, M.L, Owen, N., Bauman, A., Clavisi, O. and Leslie, E., 2000. Social-cognitive and perceived environment influences associated with physical activity in older Australians. *Preventive Medicine*, 31(1), pp.15–22.

Boulos, M.N., Brewer, A.C., Karimkhani, C., Buller, D.B. and Dellavalle, R.P., 2014. Mobile medical and health apps: State of the art, concerns, regulatory control and certification. *Online Journal of Public Health Informatics* [Online], 5(3), 229. Available from: *http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3959919/* [Accessed 29/04/2016].

Cafazzo, J.A., Casselman, M., Hamming, N., Katzman, D.K. and Palmert, M.R., 2012. Design of an mHealth app for the self-management of adolescent type 1 diabetes: a pilot study. *Journal of Medical Internet Research*, 14(3), e70.

Carlson, J.A., Sallis, J.F., Ramirez, E.R., Patrick, K. and Norman, G.J., 2012. Physical activity and dietary behavior change in Internet-based weight loss interventions: Comparing two multiple-behavior change indices. *Preventive Medicine*, 54(1), pp.50–54.

Centers for Disease Control and Prevention, 2010a. *National Center for Health statistics: Prevalence of sedentary leisure-time behavior among adults in the United States* [Online]. Atlanta, GA: Centers for Disease Control and Prevention. Available from: *http://www.cdc.gov/nchs/data/hestat/sedentary/sedentary.htm* [Accessed 10/07/2013].

Centers for Disease Control and Prevention, 2010b. *Adult obesity facts* [Online]. Atlanta, GA: Centers for Disease Control and Prevention. Available from: *http://www.cdc.gov/obesity/data/adult.html* [Accessed 14/06/2012].

Centers for Disease Control and Prevention, 2011. *Glossary of terms* [Online]. Atlanta, GA: Centers for Disease Control and Prevention. Available from: *http://www.cdc.gov/physicalactivity/everyone/glossary/index.htm* [Accessed 10/11/2013].

Centers for Disease Control and Prevention, 2012. *National Center for Health statistics: FastStats—Exercise or physical activity* [Online]. Atlanta, GA: Centers for Disease Control and Prevention. Available from: *http://www.cdc.gov/nchs/fastats/exercise.htm* [Accessed 22/06/2012].

Centers for Disease Control and Prevention, 2015. *Glossary of terms* [Online]. Atlanta, GA: Centers for Disease Control and Prevention. Available from: *http://www.cdc.gov/physicalactivity/basics/glossary/index.htm* [Accessed 15/02/2016].

Cheong, C., Cheong, F. and Filippou, J., 2013. Quick Quiz: A Gamified Approach for Enhancing Learning, *Proceedings of Pacific Asia Conference on Information Systems*, 18–22 June 2013 Jeju Island, Korea. AIS [Online]. Available from: *http://aisel.aisnet.org/pacis2013/206/* [Accessed 11/01/2017].

Connolly, C.P., Coe, D.P., Kendrick, J.M., Bassett, D.R. Jr. and Thompson, D.L., 2011. Accuracy of physical activity monitors in pregnant women. *Medicine & Science in Sports & Exercise*, 43(6), pp.1100–1105.

Conroy, D.E., Yang, C.H. and Maher, J.P., 2014. Behavior change techniques in top-ranked mobile apps for physical activity. *American Journal of Preventive Medicine*, 46(6), pp.649–652.

Council for Research Excellence, 2009. *Ground-breaking study of video viewing finds younger boomers consume more video media than any other group* [Online]. New York: Council for Research Excellence. Available from: *http://www.prnewswire.com/news-releases/ground-breaking-study-of-video-viewing-finds-younger-boomers-consume-more-video-media-than-any-other-group-61955592.html* [Accessed 24/06/2012].

Cowan, L.T., Van Wagenen, S.A., Brown, B.A., Hedin, R.J., Seino-Stephan, Y., Hall, C.P. and West, J.H., 2013. Apps of steel: Are exercise apps providing consumers with realistic expectations? A content analysis of exercise apps for presence of behavior change theory. *Health Education & Behavior*, 40(2), pp.133–139.

Craig, C., Marshall, A. and Sjöström, M., 2003. International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise*, 35, pp.1381-1395.

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I. and Petticrew, M., 2008. Developing and evaluating complex interventions: the new Medical Research Council guidance. *British Medical Journal*, 337:a1655.
Crutzen, R., 2014. The behavioral intervention technology model and intervention mapping: The best of both worlds. *Journal of Medical Internet Research* [Online], 16(8), e188. Available from: *http://www.jmir.org/2014/8/e188/* [Accessed 29/04/2013].

Daley, A.J. and Duda, J.L., 2006. Self-determination, stage of readiness to change for exercise, and frequency of physical activity in young people. *European Journal of Sport Science*, 6(4), pp.231–243.

Davies, C.A., Spence, J.C., Vandelanotte, C., Caperchione, C.M. and Mummery, W.K., 2012. Meta-analysis of Internet-delivered interventions to increase physical activity levels. *International Journal of Behavioral Nutrition and Physical Activity* [Online], 9:52. Available from: *https://ijbnpa.biomedcentral.com/articles/10.1186/1479-5868-9-52* [Accessed 05/03/2014].

Deci., E.L., 1975. *Intrinsic motivation*. New York: Plenum.

Deci, E.L., Koestner, R. and Ryan, R.M., 2001. Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. *Review of Educational Research*, 71(1), pp.1–27.

Deci, E.L. and Olson, B.C., 1989. Motivation and competition: Their role in sports. In: J.H. Goldstein, ed. *Sports, games, and play*. 2nd ed. Hillsdale, NJ: Erlbaum, pp.83–110.

Deci, E.L. and Ryan, R.M., 1985. *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Publishing Co.

Deci, E.L. and Ryan, R.M., 2000. The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), pp.227–268.

Deci, E.L. and Ryan, R.M., 2012. Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. In: R.M. Ryan, ed. *The Oxford handbook of human motivation*. Oxford, UK: Oxford University Press, pp.85–107.

Deci, E.L. and Ryan, R.M., 2014. Autonomy and need satisfaction in close relationships: Relationships motivation theory. In: N. Weinstein, ed. *Human motivation and interpersonal relationships: Theory, research, and applications.* Dordrecht, Netherlands: Springer, pp.53–73.

Denny, P., 2013. The effect of virtual achievements on student engagement. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 27 April–2 May, 2013 Paris, France. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2470763* [Accessed 13/01/2017].

Depura, K. and Garg, M., 2012. Application of online gamification to new hire onboarding. *Proceedings of the 2012 Third International Conference on Services in Emerging markets*, 12–15 December 2012 Washington, DC, USA. Washington

DC:IEEE Computer Society [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2474158* [Accessed 11/01/2017].

DeSmet, A., Van Cleemput, K., Bastiaensens, S., Poels, K., Vandebosch, H., Malliet, S., Verloigne, M., Vanwolleghem, G, Mertens, L., Cardon, G. and De Bourdeaudhuij, I., 2016. Bridging behavior science and gaming theory: Using the Intervention Mapping Protocol to design a serious game against cyberbullying. *Computers in Human Behavior*, 56, pp.337-351.

Deterding, S., 2011. Situated motivational affordances of game elements: A conceptual model. *Proceedings of CHI 2011 Gamification Workshop*, 7–12 May 2011 Vancouver, BC, Canada. New York: ACM [Online]. Available from: *https://www.researchgate.net/publication/273947177_Gamification_Toward_a_definition* [Accessed 18/07/2013].

Deterding, S., 2016. Contextual Autonomy Support in Video Game Play: A Grounded Theory. *Proceedings of CHI 2016 Gamification Workshop*, 7–12 May 2016 San Jose, CA, USA. New York: ACM [Online]. Available from: *https://dl.dropboxusercontent.com/u/220532/00%20Publications/p3931-deterding.pdf* [Accessed 25/03/2016].

Deterding, S., Dixon, D., Khaled, R. and Lennart, N., 2011. From game design elements to gamefulness: Defining "gamification". *Proceedings of MindTrek '11,* 28–30 September 2011 Tampere, Finland. New York: ACM [Online]. Available from: *https://www.researchgate.net/publication/230854710_From_Game_Design_Elements_to_Gamefulness_Defining_Gamification* [Accessed 18/07/2013].

DiClemente, C. and Prochaska, J.O., 1998. Toward a comprehensive, transtheoretical model of change: Stages of change and addictive behaviors. In: W.R. Miller and N. Heather, eds. *Treating addictive behaviors*. 2nd ed. New York and London: Plenum Press, pp.3–27.

Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, C., Pagés, C. and Martínez-Herráiz, 2013. Gamifying learning experiences: Practical implications and outcomes. *Computers & Education*, 63, pp.380-392.

Dong, T., Dontcheva, M., Joseph, D., Karahalios, K., Newman, M.W. and Ackerman, M.S., 2012. Discovery-based games for learning software. *Proceedings of the 2012 SIGCHI conference on Human Factors in Computing Systems*, 5–10 May 2012 Austin, TX, USA. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2208358* [Accessed 13/01/2017].

Doshi, A., Patrick, K., Sallis, J.F. and Calfas, K., 2003. Evaluation of physical activity web sites for behavior change theories. *Annals of Behavioral Medicine*, 25(2), pp.105–111.

Downes-Le Guin, T., Baker, R., Mechling, J. and Ruyle, E., 2012. Myths and realities of respondent engagement in online surveys. *International Journal of Market Res*earch, 54(5), pp.613-633.

Entertainment Software Association, 2010. *2010 sales, demographic and usage data: Essential facts about the computer and video game industry* [Online]. Washington, DC: Entertainment Software Association. Available from:

http://isfe.eu/sites/isfe.eu/files/attachments/esa_ef_2010.pdf [Accessed 14/07/2013].

Entertainment Software Association, 2013. *Essential facts about the computer and video game industry* [Online]. Washington, DC: Entertainment Software Association. Available from: *http://www.isfe.eu/sites/isfe.eu/files/attachments/esa_ef_2013.pdf* [Accessed 12/10/2014].

Entertainment Software Association, 2015. *Essential facts about the computer and video game industry* [Online]. Washington, DC: Entertainment Software Association. Available from: *http://www.theesa.com/wp-content/uploads/2015/04/ESA-Essential-Facts-2015.pdf* [Accessed 13/07/2016].

Fahey, T.D., Insel, P.M and Roth, W.T, 2011. *Fit & well: Core concepts and labs in physical fitness and wellness*. New York: McGraw-Hill.

Farzan, R., DiMicco, J.M., Millen, D.R., Brownholtz, B., Geyer, W. and Dugan, C., 2008. Results from deploying a participation incentive mechanism within the enterprise, *Proceedings of the twenty-sixth annual SIGCHI conference on Human factors in computing systems*, 5–10 April 2008 Florence, Italy. New York: ACM [Online]. Available from: *http://130.216.33.163/courses/compsci747s2c/lectures/paul/Farzan_enterprise.pdf* [Accessed 11/01/2017].

Feito, Y., Bassett, D.R., Tyo, B. and Thompson, D.L., 2011. Effects of body mass index and tilt angle on output of two wearable activity monitors. *Medicine & Science in Sports & Exercise*, 43(5), pp.861–866.

File, T., 2013. *Computer and Internet use in the United States: Population characteristics* [Online]. Current Population Survey Reports, P20-568. Washington, DC: U.S. Census Bureau. Available from: *http://www.census.gov/prod/2013pubs/p20-569.pdf* [Accessed 02/06/2014].

Fitocracy, 2013. *Fitocracy* [Online]. New York: Fitocracy. Available from: *https://www.fitocracy.com* [Accessed 20/10/2013 and 10/05/2016].

Fitz-Walter, Z., Tjondronegoro, D. and Wyeth, P., 2012. A gamified mobile application for engaging new students at university orientation. *Proceedings of the 24th Annual Conference of the Australian Computer-Human Interaction Special Group*, 26–30 November 2012 Melbourne, Australia. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2414560* [Accessed 14/01/2017].

Fortier, M.S., Duda, J. L., Guerin, E. and Teixeira, P.J., 2012. Promoting physical activity: Development and testing of self-determination theory-based interventions. *International Journal of Behavioral Nutrition and Physical Activity*, 9:20, pp.1–14.

Franco G., 1999. Ramazzini and workers' health. *Lancet,* 354(9181), pp.858–861.

Frederick-Recascino, C.M. and Ryan, R.M., 1995. Self-determination in sport: A review using cognitive evaluation theory. *International Journal of Sport Psychology*, 26, pp.5–23.

Gale, N.K., Heath, G., Cameron, E., Rashid, S. and Redwood, S., 2013. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology* [Online], 13:117. Available from: *http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3848812/* [Accessed 22/04/2015].

Gartner, 2011. *Gartner says by 2015, more than 50 percent of organizations that manage innovation processes will gamify those processes* [Online]. Available from: *http://www.gartner.com/it/page.jsp?id=1629214* [Accessed 27/01/2016].

Gnauk, B., Dannecker, L. and Hahmann, M., 2012. Leveraging gamification in demand dispatch systems. *Proceedings of the 2012 Joint EDBT/ICDT Workshops,* 26–30 March 2012 Berlin. Berlin, Germany: ACM, pp.103–110.

Gotsis, M., Wang, H., Spruijt-Metz, D., Jordan-Marsh, M. and Valente, T.W., 2013. Wellness partners: Design and evaluation of a web-based physical activity diary with social gaming features for adults. *JMIR Research Protocols* [Online], 2(1), e10. Available from: *http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3628151/* [Accessed 18/06/2013].

Grant, S. and Betts, B., 2013. Encouraging user behaviour with achievements: An empirical study. *Proceedings of the 10th Working Conference on Mining Software Repositories*, 18–19 May 2013 San Francisco, CA, USA. New Jersey: IEEE [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2487101* [Accessed 11/01/2017].

Greaves, C.J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P.H., Schwarz, P. and The IMAGE Study Group, 2011. Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health* [Online], 11:119. Available from: *http://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-11-119* [Accessed 14/07/2013].

Grøntved, A. and Hu, F.B., 2011. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: A meta-analysis. *Journal of the American Medical Association*, 305(23), pp.2448–2455.

Gustafsson, A. and Bång, M., 2008. Evaluation of a pervasive game for domestic energy engagement among teenagers. *Proceedings of the 2008 International Conference on Advances in Computer Entertainment Technology*, 3–5 December 2008 Yokohama, Japan. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?id=1501804* [Accessed 13/01/2017].

Halan, S., Rossen, B., Cendan, J. and Lok, B., 2010. High Score! - Motivation Strategies for User Participation in Virtual Human Development. *Proceedings of the international conference on Intelligent Virtual Agents*, 20–22 September 2010 Philadelphia, PA, USA. Berlin/Heidelberg: Springer [Online]. Available from: *http://link.springer.com/chapter/10.1007/978-3-642-15892-6_52#page-1* [Accessed 11/01/2017].

Hamari, J. and Koivisto, J., 2013. Social motivations to use gamification: an empirical study of gamifying exercise. *Proceedings of the European Conference on Information Systems*, 5–8 June 2013 Utrecht, The Netherlands. AIS [Online]. Available from: *http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1328&context=ecis2013_cr* [Accessed 11/01/2017].

Hamari, J., Koivisto, J. and Sarsa, H., 2014. Does gamification work?—A literature review of empirical studies on gamification. *Proceedings of the 47th Hawaii International Conference on System Sciences*, 6–9 January 2014 Waikoloa, HI, USA. Piscataway, New Jersey: IEEE, pp.3025–3034.

Helf, C. and Hlavacs, H., 2016. Apps for life change: Critical review and solution directions. *Entertainment Computing*, 14, pp.17–22.

Hori, Y., Tokuda, Y., Miura, Y., Hiyama, A. and Hirose, M., 2013. Communication pedometer: a discussion of gamified communication focused on frequency of smiles. *Proceedings of the 4th Augmented Human International Conference*, 7–8 March 2013 Stuttgart, Germany. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2459272&dl=ACM&coll=DL&CFID=893154911&CFTOKEN=89238578* [Accessed 31/01/17].

Hu, F.B., Li, T.Y., Colditz, G.A., Willett, W.C. and Manson, J.E., 2003. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *Journal of the American Medical Association*, 289(14), pp.1785–1791.

Huotari, K. and Hamari, J., 2012. Defining gamification: A service marketing perspective. *Proceedings of the 16th International Academic MindTrek Conference*, 3–5 October 2012 Tampere, Finland. New York: ACM, pp.17–22.

Hurling, R., Catt, M., De Boni, M., Fairley, B.W., Hurst, T., Murray, P., Richardson, A. and Sodhi, J.S., 2007. Using Internet and mobile phone technology to deliver an automated physical activity program: Randomized controlled trial. *Journal of Medical Internet Research* [Online], 9(2): e7. Available from: *http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1874722/?report=printable* [Accessed 20/02/2012].

International Data Corporation, 2013. *Always connected: How smartphones and social keep us engaged* [Online]. Framingham, MA: IDC. Available from: *http://www.nu.nl/files/IDC-Facebook%20Always%20Connected%20(1).pdf* [Accessed 14/07/2013].

Juul, J., 2003. The game, the player, the world: Looking for a heart of gameness. In: M. Copier and J. Raessens, eds. *Level Up: Digital Games Research Conference Proceedings*, 4–6 November 2003 Utrecht. Utrecht: Utrecht University, pp.30–45.

Kapp, K.M., 2012. *The gamification of learning and instruction: Game-based methods and strategies for training and education*. San Francisco: Pfeiffer.

Kato, P.M., 2012. Evaluating efficacy and validating games for health. *Games for Health Journal*, 1(1), pp.74–76.

King, D., Greaves, F., Exeter, C. and Darzi, A., 2013. 'Gamification': Influencing health behaviours with games. *Journal of the Royal Society of Medicine*, 106(3), pp.76–78.

La Sierra University, 2016. *About La Sierra University* [Online]. Riverside: La Sierra University. Available from: https://lasierra.edu/about [Accessed 24/05/16].

Lee, H. and Doh, Y.Y., 2012. A study on the relationship between educational achievement and emotional engagement in a gameful interface for video lecture systems. *Proceedings of the 2012 International Symposium on Ubiquitous Virtual Reality*, 22–25 August 2012 Daejeon, Korea. New York: IEEE, pp.34–37.

Li, W., Grossman, T. and Fitzmaurice, G., 2012. GamiCAD: a gamified tutorial system for first time autocad users. *Proceedings of the 25th annual ACM symposium on User interface software and technology*, 7–10 October 2011 Cambridge, MA, USA. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2380131* [Accessed 11/01/2017].

Lim, S.S., Vos, T., Flaxman, A.D., Danaei, G., Shibuya, K., Adair-Rohani, H. et al., 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380(9859), pp.2224-2260.

Lister, C., West, J.H., Cannon, B., Sax, T. and Brodegard, D., 2014. Just a fad? Gamification in health and fitness apps. *JMIR Serious Games* [Online], 2(2). Available from: *http://games.jmir.org/2014/2/e9/* [Accessed 27/01/2016].

Lister, C., West, J.H., Richards, R., Crookston, B., Hall, P.C. and Redelfs, A.H., 2013. Technology for health: A qualitative study on barriers to using the iPad for diet change. *Health*, 5(4), pp.761-768.

Liu, Y., Alexandrova, T. and Nakajima, T., 2011. Gamifying intelligent environments. *Proceedings of the 2011 International ACM Workshop on Ubiquitous Meta User Interfaces*, 1 December 2011 Scottsdale, AZ, USA. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?id=2072655* [Accessed 15/01/2017].

Loprinzi, P.D., Branscum, A., Hanks, J. and Smit, E., 2016. Healthy lifestyle characteristics and their joint association with cardiovascular disease biomarkers in US adults. *Mayo Clinic Proceedings*, 91(4), pp.432–442.

Loma Linda University, 2016. *Loma Linda University 10-year Fall Term Student Enrollments for 2007-2016* [Online]. Loma Linda: Loma Linda University. Available from: http://home.llu.edu/about-us/quick-facts/loma-linda-university-10-year-fall-term-student-enrollments-for-2007-2016 [Accessed 24/05/16].

Lowry, R., 2011. *Concepts & applications of inferential statistics* [Online]. Poughkeepsie, NY: Richard Lowry. Available from: *http://vassarstats.net/textbook/ch12a.html* [Accessed 13/05/2016].

MacAuley, D., 1994. A history of physical activity, health and medicine. *Journal of the Royal Society of Medicine*, 87(1):32-35.

MacAuley, E., Duncan, T. and Tammen, V.V., 1989. Psychometric properties of the Intrinsic Motivation Inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sport*, 60(1), pp.48–58.

Marcus, B.H. and Forsyth, L.H., 2009. *Motivating people to be physically active*. 2nd ed. Champaign, IL: Human Kinetics.

Marcus, B.H., Williams, D.M., Dubbert, P.M., Sallis, J.F., King, A.C., Yancey, A.K., Franklin, B.A., Buchner, D., Daniels, S.R. and Claytor, R.P., 2006. Physical activity intervention studies: What we know and what we need to know: A scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity); Council on Cardiovascular Disease in the Young; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research. *Circulation*, 114(24), pp.2739–2752.

Mark, R., Rhodes, R.E.., Warburton, D.E.R. and Bredin, S.S.D., 2008. Interactive video games and physical activity: A review of the literature and future directions. *Health & Fitness Journal of Canada*, 1(1), pp.14–24.

Markland, D. & Tobin, V., 2004. A modification to the Behavioural Regulation in Exercise Questionnaire to include an assessment of amotivation. *Journal of Sport and Exercise Psychology,* 26*,* pp.191–196*.*

McGonigal, J., 2011. *Reality is broken: Why games make us better and how they can change the world*. New York: Penguin Press.

McKenzie, J.F., Neiger, B.L. and Thackeray, R., 2012. *Planning, implementing, & evaluating health promotion programs: A primer*. San Francisco: Pearson Education.

Mekler, E.D., Bopp, J.A., Tuch, A.N. and Opwis, K., 2014. A systematic review of quantitative studies on the enjoyment of digital entertainment games. *Proceedings of the 32nd Annual SIGCHI Conference on Human Factors in Computing Systems—CHI'14*, 26 April–1 May 2014 Toronto. New York: ACM Press, pp.927–936.

Meloni, W. and Gruener, W., 2012. Gamification in 2012: Market update: Consumer and enterprise market trends. *Gaming Business Review* [Online]. Encinitas, CA. Available from: *http://gamingbusinessreview.com/wp-content/uploads/2012/05/Gamification-in-2012-M2R3.pdf* [Accessed 04/06/2014].

Michie, S., Ashford, S., Sniehotta, F.F., Dombrowski, S.U., Bishop, A. and French, D.P., 2011. A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALO-RE taxonomy. *Psychology & Health*, 26(11), pp.1479–1498.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M.P., Cane, J. and Wood, C.E., 2013. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine*, 46(1), pp.81–95.

Michie, S., van Stralen, M.M. and West, R., 2011. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science* [Online], 6:42. Available from: *https://implementationscience.biomedcentral.com/articles/10.1186/1748-5908-6-42* [Accessed 17/01/2014].

Middelweerd, A., Mollee, J.S., van der Wal, C.N., Brug, J. and Te Velde, S.J., 2014. Apps to promote physical activity among adults: A review and content analysis. *The International Journal of Behavioral Nutrition and Physical Activity*

[Online], 11:97. Available from: *https://ijbnpa.biomedcentral.com/articles/10.1186/s12966-014-0097-9* [Accessed 06/05/2016].

Mobihealthnews, 2011. *Mobile social and fun games for health* [Online]. Cambridge, MA: HIMSS Media. Available from: *http://mobihealthnews.com/offers/mobile_games_for_health* [Accessed 22/06/2012].

Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G. and The PRISMA Group, 2009. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLOS Medicine* [Online], 6(7): e1000097. Available from: *http://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1000097* [Accessed 18/04/2016].

Montola, M., Nummenmaa, T., Lucero, A., Boberg, M. and Korhonen, H., 2009. Applying game achievement systems to enhance user experience in a photo sharing service. *Proceedings of the 13th International MindTrek Conference: Everyday Life in the Ubiquitous Era*, 30 September–2 October 2009 Tampere, Finland. New York: ACM [Online]. Available from: *http://dl.acm.org/citation.cfm?id=1621859* [Accessed 11/01/2017].

Moore, G., Audrey, S., Barker, M., Bond, L., Bonell, C., Hardeman, W., Moore, L., O'Cathain, A., Tinati, T., Wight, D. and Baird, J., 2015. Process evaluation of complex interventions: Medical Research Council guidance. *British Medical Journal*, 350:h1258.

Moreno Murcia, J.A., Gimeno, E.C. and Camacho, A.M., 2007. Measuring self-determination motivation in a physical fitness setting: Validation of the behavioral regulation in exercise questionnaire-2 (BREQ-2) in a Spanish sample. *Journal of Sports Medicine and Physical Fitness*, 47(3), pp.366–374.

Mozaffarian, D., Hao, T., Rimm, E.B., Willett, W.C. and Hu, F.B., 2011. Changes in diet and lifestyle and long-term weight gain in women and men. *New England Journal of Medicine*, 364(25), pp.2392–2404.

Munson, S.A., Poole, E., Perry, D.B. and Peyton, T., 2015. Gamification and health. In: S.P. Walz & S. Detering, eds. *The gameful world: Approaches, issues, applications*. Cambridge, MA & London: MIT Press, pp. 597–623.

Nicholson, S., 2012. A user-centered theoretical framework for meaningful gamification. *Paper presented at Games+Learning+Society 8.0*, 13–15 June 2012 Madison, WI. Syracuse, NY: Syracuse University. [Online]. Available from: *http://scottnicholson.com/pubs/meaningfulframework.pdf* [Accessed 18/06/2013].

Osorio, G., Moffat, D.C. and Sykes, J., 2012. Exergaming, exercise, and gaming: Sharing motivations. *Games for Health Journal*, 1(3), pp.205–210.

Owen, N., Healy, G.N., Matthews, C.E. and Dunstan, D.W., 2010. Too much sitting: The population health science of sedentary behavior. *Exercise and Sport Sciences Reviews*, 38(3), pp.105–113.

Pagoto, S., Schneider, K., Jojic, M., DeBiasse, M. and Mann, D., 2013. Evidence-based strategies in weight-loss mobile apps. *American Journal of Preventive Medicine*, 45(5), pp.576–582.

Pate, R.R., O'Neill, J.R. and Lobelo, F., 2008. The evolving definition of 'sedentary'. *Exercise and Sport Sciences Reviews*, 36(4), pp.173–178.

Patrick, H. and Williams, G.C., 2012. Self-determination theory: Its application to health behavior and complementarity with motivational interviewing. *International Journal of Behavioral Nutrition and Physical Activity* [Online], 9:18. Available from: *https://ijbnpa.biomedcentral.com/articles/10.1186/1479-5868-9-18* [Accessed 09/06/2013].

Payne, H. E., Moxley, V.B.A. and MacDonald, E., 2015. Health behavior theory in physical activity game apps: A content analysis. *JMIR Serious Games* [Online], 3(2): e4. Available from: *http://games.jmir.org/2015/2/e4/* [Accessed 29/04/2016].

Peng, W., Lin, J., Pfeiffer, K. and Winn, B., 2012. Need Satisfaction Supportive Game Features as Motivational Determinants: An Experimental Study of a Self-Determination Theory Guided Exergame. *Media Psychology*, 15, pp.175-196.

Pereira, P., Duarte, E., Rebelo, F. and Noriega, P., 2014. A review of gamification for health-related contexts. *Proceedings of the 3rd International Conference, DUXU 2014, held as part of HCI International 2014,* 22-27 June 2014 Heraklion, Crete, Greece. In: A. Marcus, ed. *DUXU 2014, Part II, Lecture Notes in Computer Science, Vol. 8158*. Springer International Publishing Switzerland, pp.742–753.

Pescatello, L.S., Arena, R., Riebe, D., Thompson, P. and American College of Sports Medicine (ACSM), 2014. *ACSM's guidelines for exercise testing and prescription*. 9th ed. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins Health.

PR Newswire, 2016. *Global gamification market value of USD 11.10 billion by 2020—Analysis, trends & opportunities report 2016-2020—key vendors: Leveleleven, Arcaris Inc. & Badgeville Inc.* [Online]. Stockholm, Sweden: Cision Company. Available from: *http://www.prnewswire.com/news-releases/global-gamification-market-value-of-usd-1110-billion-by-2020---analysis-trends--opportunities-report-2016-2020---key-vendors-leveleleven-arcaris-inc--badgeville-inc-300222904.html* [Accessed 13/06/2016].

Prince, S.A., Adamo, K.B., Hamel, M.E., Hardt, J., Gorber, S.C. and Tremblay, M., 2008. A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity* [Online], 5:56. Available from: *http://ijbnpa.biomedcentral.com/articles/10.1186/1479-5868-5-56* [Accessed 18/06/2013].

Przybylski, A. K., Rigby, C.S. and Ryan, R.M., (2010). A motivational model of video game engagement. *Review of General Psychology*, 14(2), 154–166.

Raynor, H.A., Bond, D.S., Freedson, P.S. and Sisson, S.B., 2012. Sedentary behaviors, weight, and health and disease risks. *Journal of Obesity* [Online], Article ID 852743. Available from: *downloads.hindawi.com/journals/specialissues/904013.pdf* [Accessed 20/10/2013].

Recio, G., 2012. Motivation: Getting your game on. *IDEA Fitness Journal*, 9(5), pp.30–33.

Reeve, J., 2016. A grand theory of motivation: Why not? *Motivation and Emotion*, 40(1), pp.31-35.

Reeves, B. and Read, J.L., 2013. *Total engagement: Using games and virtual worlds to change the way people work and businesses compete*. 2nd ed. Boston, MA: Harvard Business School Press.

Reilly, J.J., Penpraze, V., Hislop, J., Davies, G., Grant, S. and Paton, J.Y., 2008. Objective measurement of physical activity and sedentary behaviour: Review with new data. *Archives of Disease in Childhood*, 93(7), pp.614–619.

Rigby, C.S. and Ryan, R.M., 2007. *The player experience of need satisfaction (PENS): An applied model and methodology for understanding key components of the player experience* [Online]. Celebration, FL: Immersyve. Available from: *http://natronbaxter.com/wp-content/uploads/2010/05/PENS_Sept07.pdf* [Accessed 03/07/2013].

Rigby, C.S. and Ryan, R.M., 2011. *Glued to games: How video games draw us in and hold us spellbound*. Santa Barbara, CA: Praeger.

Riley, W.T., Rivera, D.E., Atienza, A.A., Nilsen, W., Allison, S.M. and Mermelstein, R, 2011. Health behavior models in the age of mobile interventions: Are our theories up to the task? *Translational Behavioral Medicine*, 1(1), pp.53-71.

Ritchie, J. and Lewis, J., eds., 2003. *Qualitative research practice: A guide for social science students and researchers*. London: Sage Publications.

Roberts, G. and Treasure, D., 2012. *Advances in motivation in sport and exercise.* 3rd ed*.* Champaign, IL: Human Kinetics.

Rose, K.J., Koenig, M. and Wiesbauer, F., 2013. Evaluating success for behavioral change in diabetes via mHealth and gamification: MySugr's keys to retention and patient engagement. *Diabetes Technology & Therapeutics*, 15, A114.

Ryan, R.M., 2012. Motivation and the organization of human behavior: Three reasons for the reemergence of a field. In R.M. Ryan, ed., *Oxford handbook of human motivation*. Oxford, England: Oxford University Press, pp. 3-10.

Ryan, R.M. and Connell, J.P., 1989. Perceived locus of causality and internalization: Examining reasons for acting in two domains. *Journal of Personality & Social Psychology,* 57(5), pp.749–761.

Ryan, R.M. and Deci, E.L., 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 55(1), pp.68–78.

Ryan, R.M., Patrick, H., Deci, E. L. and Williams, G.C., 2008. Facilitating health behaviour change and its maintenance: Interventions based on self-determination theory. *The European Health Psychologist,* 10, pp.2–5.

Ryan, R.M., Rigby, C.S. and Przybylski, A., 2006. The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion*, 30(4), pp.347–363.

Ryan, R.M., Williams, G.C., Patrick, H. and Deci, E.L., 2009. Self-determination theory and physical activity: The dynamics of motivation in development and wellness. *Hellenic Journal of Psychology*, 6, pp.107–124.

Sailer, M., Hense, J., Mandl, H. and Klevers, M., 2013. Psychological perspectives on motivation through gamification. *Interaction Design and Architecture(s) Journal— IxD&A*, 19, pp.28–37.

Salen, K. and Zimmerman, E., 2004. *Rules of play: Game design fundamentals.* Cambridge: MIT Press.

Sallis, J.F. and Hovell, M.F., 1990. Determinants of exercise behavior. *Exercise and Sport Sciences Reviews*, 18, pp.307–330.

Sallis, J.F., Hovell, M.F. and Hofstetter, C.R., 1992. Predictors of adoption and maintenance of vigorous physical activity in men and women. *Preventive Medicine*, 21(2), pp.237–251.

Sallis, J.F. and Saelens, B.E., 2000. Assessment of physical activity by self-report: Status, limitations, and future directions. *Research Quarterly for Exercise and Sport*, 71(2 Suppl), S1–S14.

Sarason, B.R., Sarason, I.G. and Gurung, R.A.R, 2001. Close personal relationships and health outcomes: A key to the role of social support. In: B.R. Sarason & S. Duck eds., *Personal relationships: Implications for clinical and community psychology*, pp.15-41. West Sussex, UK: Wiley.

Schlagenhaufer, C. and Amberg, M., 2014. Psychology theories in gamification: A review of information systems literature. In: N.M. Hindi, A. Ghoneim, M. Themistocleous and G. Viscusi, eds. *CD-ROM/Online Proceedings of the European, Mediterranean and Middle Eastern Conference on Information Systems (EMCIS),* 27–28 October 2014 Doha, Qatar. Qatar University: Doha, Qatar [Online]. Available from: *http://emcis.eu/Emcis_archive/EMCIS/EMCIS2014/EMCISWebsite/EMCIS%202014%20Proceedings/emcis2014_submission_15.pdf* [Accessed 13/11/2014].

Schuna, J.M., Johnson, W.D. and Tudor-Locke, C., 2013. Adult self-reported and objectively monitored physical activity and sedentary behavior: NHANES 2005-2006. *International Journal of Behavioral Nutrition and Physical Activity* [Online], 10:126. Available from: *https://ijbnpa.biomedcentral.com/articles/10.1186/1479-5868-10-126* [Accessed 13/11/2014].

Seaborn, K. and Fels, D.I., 2015. Gamification in theory and action: A survey. *International Journal of Human-Computer Studies*, 74, pp.14–31.

Sintek, N.J. and Pronk, N.P., 2013. Optimizing work with play: A gamification primer. *ACSM's Health & Fitness Journal*, 17(3), pp.35–39.

Smith, J. and Firth, J., 2011. Qualitative data analysis: The framework approach. *Nurse Researcher*, 18(2), pp.52–62.

Sola, D., Couturier, J. and Voyer, B.G., 2015. Unlocking patient activation in chronic disease care. *British Journal of Healthcare Management*, 21(5), pp.220–225.

Spillers, F. and Asimakopoulos, S., 2014. Does social user experience improve motivation for runners? A diary study comparing mobile health applications. In: A. Marcus, ed. *Proceedings of the 3rd International Conference on Design, User Experience, and Usability (DUXU),* 22–27 June 2014 Heraklion, Crete, Greece. Heraklion: DUXU 2014, PT IV, LNCS 8520, pp.358–369.

Tamborini, R., Grizzard, M., Bowman, N.D., Reinecke, L., Lewis, R.J. and Eden, A., 2011. Media enjoyment as need satisfaction: The contribution of hedonic and nonhedonic needs. *Journal of Communication*, 61(6), pp.1025–1042.

Tarini, P., 2012. Curiosity, hope, and vision: The role of the Robert Wood Johnson Foundation's pioneer portfolio in funding early health game research. *Games for Health Journal*, 1(1), pp.7–8.

Teixeira, P.J., Carraça, E.V., Markland, D., Silva, M.N. and Ryan, R.M., 2012. Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity* [Online], 9:78. Available from: *http://www.ijbnpa.org/content/9/1/78* [Accessed 27/01/2016].

Thom, J., Millen, D.R., and DiMicco, J., 2012. Removing gamification from an enterprise SNS. *Proceedings of the ACM 2012 Conference on Computer Supported Cooperative Work*, 11–15 February 2012 Seattle, WA, USA. New York: ACM, pp.1067–1070.

Thorsteinsen, K., Vittersø, J. and Svendsen, G. B., 2014. Increasing physical activity efficiently: An experimental pilot study of a website and mobile phone intervention. *International Journal of Telemedicine and Applications* [Online], Article ID 746232. Available from: *http://dx.doi.org/10.1155/2014/746232* [Accessed 27/01/2016].

Troiano, R.P., Berrigan, D., Dodd, K.W., Mâsse, L.C., Tilert, T. and McDowell, M., 2008. Physical activity in the United States measured by accelerometer. *Medicine & Science in Sports & Exercise*, 40(1), pp.181–188.

Tucker, J.M., Welk, G.J. and Beyler, N.K., 2011. Physical activity in U.S. adults: Compliance with the physical activity guidelines for Americans. *American Journal of Preventive Medicine*, 40(4), pp.454–461.

Tudor-Locke, C., Craig, C.L., Thyfault, J.P. and Spence, J.C., 2013. A step-defined sedentary lifestyle index: <5000 steps/day. *Applied Physiology, Nutrition, and Metabolism*, 38(2), pp.100–114.

U.S. Department of Health and Human Services, 1996. *Physical activity and health: A report of the surgeon general.* Atlanta, GA: U.S. Department of Health and
Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.

U.S. Department of Health and Human Services, 2008. *2008 physical activity guidelines for Americans summary*. Washington, DC: Office of Disease Prevention and Health Promotion.

U.S. Department of Health and Human Services, 2009. *Summary health statistics for U.S. Adults: National health interview survey, 2008.* Washington, DC: Center for Disease Control and Prevention and National Center for Health Statistics, 10(242).

U.S. Department of Health and Human Services, 2010. *Healthy people 2010: Understanding and improving Health*. 2nd ed. Washington, DC: U.S. Government Printing Office, November 2000. [Online] Available from: *http://www.healthypeople.gov/2010/document/pdf/uih/2010uih.pdf.*

Vallerand, R.J, Deci, E.L and Ryan, R.M., 1987. Intrinsic motivation in sport. In K. Pandolf, ed. *Exercise and sport science reviews, Vol 15*. New York: Macmillan, pp. 389-425.

Vallerand, R.J. and Losier, G.F., 1999. An integrative analysis of intrinsic and extrinsic motivation in sport. *Journal of Applied Sport Psychology*, 11(1), pp.142–169.

Van den Berg, M.H., Schoones, J.W. and Vliet Vlieland, T.P.M., 2007. Internet-based physical activity interventions: A systematic review of the literature. *Journal of Medical Internet Research* [Online], 9(3), e26. Available from: *http://www.jmir.org/2007/3/e26/* [Accessed 05/03/2014].

Van den Berghe, L., Vansteenkiste, M., Cardon, G., Kirk, D. and Haerens, L., 2014. Research on self-determination in physical education: Key findings and proposals for future research. *Physical Education and Sport Pedagogy*, 19(1), pp.97–121.

Wendel-Vos, W., Droomers, M., Kremers, S., Brug, J. and van Lenthe, F., 2007. Potential environmental determinants of physical activity in adults: A systematic review. *Obesity Reviews*, 8(5), pp.425–440.

Werbach, K. and Hunter, D., 2012. *For the win: How game thinking can revolutionize your business*. Philadelphia, PA: Wharton Digital Press.

West, J.H., Hall, P.C., Hanson, C.L., Barnes, M.D., Giraud-Carrier, C. and Barrett, J., 2012. There's an app for that: Content analysis of paid health and fitness apps. *Journal of Medical Internet Research* [Online], 14(3): e72. Available from: *http://www.jmir.org/2012/3/e72/* [Accessed 24/06/2012].

White, R.W., 1959. Motivation reconsidered: The concept of competence. *Psychological Review*, 66(5), pp.297-333.

Whitt-Glover, M.C., Taylor, W.C., Heath, G.W. and Macera, C.A., 2007. Self-reported physical activity among blacks: Estimates from national surveys. *American Journal of Preventive Medicine*, 33(5), pp.412–417.

Wijsman, C.A., Westendorp, R.G., Verhagen, E.A., Catt, M., Slagboom, P.E., de Craen, A.J., Broekhuizen, K., van Mechelen, W., van Heemst, D., van der Ouderaa, F. and Mooijaart, S.P., 2013. Effects of a web-based intervention on physical activity and metabolism in older adults: Randomized controlled trial. *Journal of Medical Internet Research* [Online], 15(11): e233. Available from: *http://www.jmir.org/article/citations/2843* [Accessed 05/03/2014].

Wikipedia, 2016. *Inland Empire* [Online]. Wikipedia, the Free Encyclopedia. Available from: https://en.wikipedia.org/w/index.php?title=Inland_Empire&oldid=762350244 [Accessed 24/05/16].

Wisker, G., 2008. *The postgraduate research handbook.* 2nd ed. New York, NY: Palgrave Macmillan.

Witt, M., Scheiner, C. and Robra-Bissantz, S., 2011. Gamification of online idea competitions: Insights from an explorative case. In: H.U. Heis, P. Pepper, H. Schlingloff and J. Schneider, eds. *Proceedings of INFORMATIK 2011—Informatik Schafft Communities*, 4–7 October 2011 Berlin. Berlin: GI-Edition—Lecture Notes in Informatics (LNI), p.392–394.

World Health Organization, 2010. *Global recommendations on physical activity for health.* Geneva, Switzerland: World Health Organization.

Yang, C.H., Maher, J.P. and Conroy, D.E., 2015. Implementation of behavior change techniques in mobile applications for physical activity. *American Journal of Preventive Medicine*, 48(4), pp.452–455.

Zhang, P., 2008. Motivational affordances: Reasons for ICT design and use. *Communications of the ACM*, 51(11), pp.145–147.

Zichermann, G. and Cunningham, C., 2011. *Gamification by design: Implementing game mechanics in web and mobile apps*. Sebastopol, CA: O'Reilly Media.

Zuckerman, O. and Gal-Oz, A., 2014. Deconstructing gamification: Evaluating the effectiveness of continuous measurement, virtual rewards, and social comparison for promoting physical activity. *Personal and Ubiquitous Computing*, 18(7), pp.1705–1719.

APPENDIX

Table of Contents

Literature Search Methods

Search terms:
gamification AND "physical activity"

	Initial Search	**Duplicates** with Web of Science	**Additional Duplicates** with SCOPUS	**Additional Duplicates** with Pub Med	**Additional Duplicates** with Embase
Web of Science	20	N/A	N/A	N/A	N/A
SCOPUS	20	7	N/A	N/A	N/A
PubMed	8	5	2	N/A	N/A
Embase	9	2	3	1	N/A
APA PsychNET	1	0	0	0	0
TOTAL	58	14	5	1	0
Grand Total	58	44	39	38	**38**

Exclusion Criteria 1: Focused on children
Exclusion Criteria 2: Not specifically focused on physical activity behaviour
Exclusion Criteria 3: Focus on medical context/condition
Exclusion Criteria 4: Focused primarily on activity trackers
Exclusion Criteria 5: Theoretical/conceptual papers
Exclusion Criteria 6: Focused on exergames or videogames
Exclusion Criteria 7: Does not use gamification

Starting number	**EC 1**	**EC 2**	**EC 3**	**EC 4**	**EC 5**	**EC 6**
38	-5	-19	-7	-1	-1	-1
TOTAL	33	14	7	6	5	4

Four articles selected for review:

1) Ahola et al., 2013
2) Gotsis et al., 2013
3) Zuckerman & Gal-Oz, 2014
4) Thorsteinsen et al., 2014

GOOGLE SCHOLAR SEARCH

Search terms:
Initial search: gamification AND “physical activity”
Refined search: gamification AND “physical activity” AND Internet AND adults

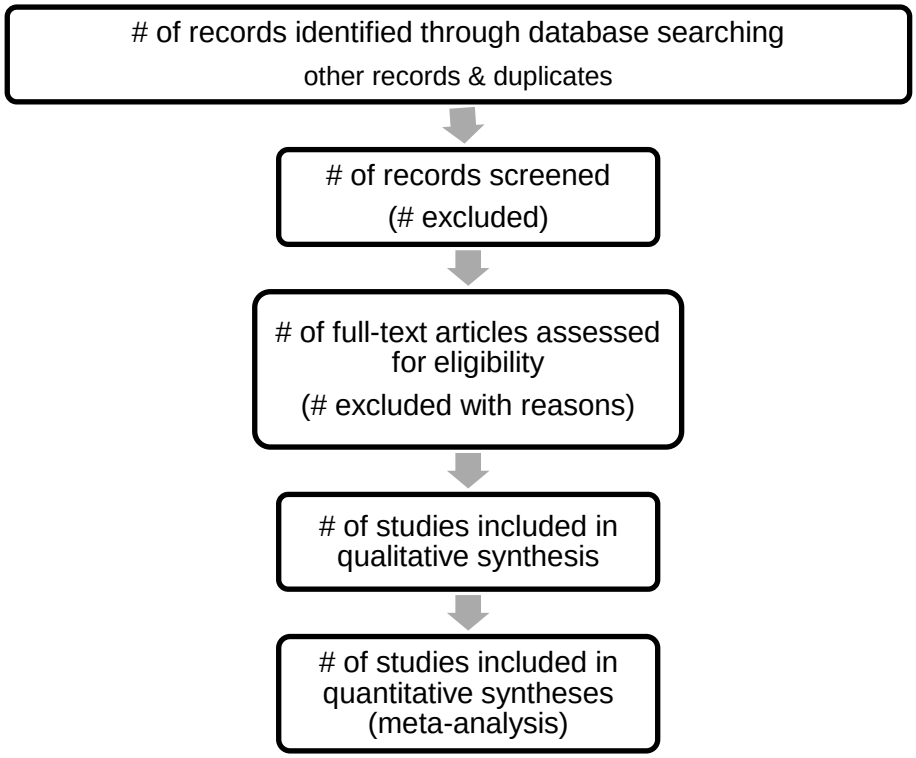
Exclusion Criteria 1: Theoretical/conceptual papers
Exclusion Criteria 2: Not specifically focused on physical activity behaviour
Exclusion Criteria 3: Focus on medical context/condition
Exclusion Criteria 4: Focused primarily on activity trackers
Exclusion Criteria 5: No evidence of any gamification

	Initial Search	Refined search	EC 1 Since 2016	EC 2 Since 2016	EC 3 Since 2016	EC 4 Since 2016	EC 5 Since 2016
Total since 2012	1,520	512	N/A	N/A	N/A	N/A	N/A
Total since 2015	651	283	N/A	N/A	N/A	N/A	N/A
Total since 2016	133	67	44	24	12	9	6

After reviewing the seven remaining articles in detail, the following was concluded:

1.) Kappen et al., 2016: Focused on technology design functional for older adults, thus, this study did not focus on gamification = excluded
2.) Mierlo et al., 2016: Theoretical paper not focused on the outcomes of physical activity motivated by gamification = excluded
3.) Journal of Holistic Health: is a theoretical paper = excluded
4.) Kwon et al., 2016: Focused on general health behaviours in relation to mhealth; not specifically focused on physical activity = excluded
5.) Wang et al., 2016: Focused on gameplay, but not physical activity = excluded
6.) Spagnolli et al., 2016: Theoretical paper and not specifically focused on physical activity = excluded

PRISMA Flow



Adapted from Moher et al. and The PRISMA Group (2009)

40-item CALO-RE Taxonomy

	Techniques	Description/Definition
1	**Provide information on consequences of behaviour in general**	*Information about the relationship between the behaviour and its possible or likely **consequences in the general case**, usually based on epidemiological data, and not personalised for the individual.*
2	**Provide information on consequences of behaviour to the individual**	*Information about the benefits and costs of action or inaction to the individual or tailored to a relevant group based on that individual's characteristics.*
3	**Provide information about others' approval**	*Involves information about what other people think about the target person's behaviour.*
4	**Provide normative information about others' behaviour**	*Involves providing information about what other people are doing, i.e., indicates that a particular behaviour or sequence of behaviours is common or uncommon amongst the population or amongst a specified group – presentation of case studies of a few others is not normative information.*
5	**Goal setting (behaviour)**	*The person is encouraged to make a behavioural resolution. This is directed towards encouraging people to decide to change or maintain change.*
6	**Goal setting (outcome)**	*The person is encouraged to set a general goal that can be achieved by behavioural means but is not defined in terms of behaviour (i.e. reduce blood pressure).*
7	**Action planning**	*Involves detailed planning of what the person will do including, as a minimum, when, in which situation and/or where to act.*
8	**Barrier identification/Problem solving**	*The person is prompted to think about potential barriers and identify ways of overcoming them.*
9	**Set graded tasks**	*Breaking down the target behaviour into smaller easier-to-achieve tasks.*
10	**Prompt review of behavioural goals**	*Involves a review or analysis of the extent to which previously set behavioural goals were achieved.*
11	**Prompt review of outcome goals**	*Involves a review or analysis of the extent to which previously set outcome goals were achieved.*
12	**Prompt rewards contingent on effort or progress towards behaviour**	*Involves the person using praise or rewards for attempts at achieving a behavioural goal.*
13	**Provide rewards contingent on successful behaviour**	*Reinforcing successful performance of the specific target behaviour (i.e. praise, encouragement or material rewards linked to specific achievement).*

Continued: 40-item CALO-RE Taxonomy continued

	Techniques	Description/Definition
14	**Shaping**	*Contingent rewards are first provided for any approximation to the target behaviour. Later, only a more demanding performance (e.g., brisk walking for 10 minutes on three days a week) would be rewarded. This is graded use of contingent rewards over time.*
15	**Prompting generalisation of a target behaviour**	*Once a behaviour is performed in a particular situation, the person is encouraged or helped to try it in another situation.*
16	**Prompt self-monitoring of behaviour**	*The person is asked to keep a record of specified behaviour/s as a method for changing behaviour.*
17	**Prompt self-monitoring of behavioural outcome**	*The person is asked to keep a record of specified measures expected to be influenced by the behaviour change (e.g. blood pressure).*
18	**Prompting focus on past success**	*Involves instructing the person to think about or list previous successes in performing the behaviour.*
19	**Provide feedback on performance**	*This involves providing the participant with data about their own recorded behaviour.*
20	**Provide information on <u>where and when</u> to perform the behaviour**	*Involves telling the person about when and where they might be able to perform the behaviour.*
21	**Provide instruction on how to perform the behaviour**	*Involves telling the person how to perform a behaviour or preparatory behaviours (verbally or in written form).*
22	**Model/demonstrate the behaviour**	*Involves showing the person how to perform a behaviour (physical or visual; in person or remotely).*
23	**Teach to use prompts/cues**	*Person is taught to identify environmental prompts.*
24	**Environmental restructuring**	*Person is prompted to alter the environment to support target behaviour.*
25	**Agreement behavioural contract**	*Involves a written agreement on the performance of an explicitly specified behaviour (witnessed).*
26	**Prompt practice**	*Prompt person to rehearse and repeat the behaviour (or preparatory behaviour) numerous times.*
27	**Use follow-up prompts**	*Intervention components are gradually reduced in intensity, duration and frequency over time.*
28	**Facilitate social comparison**	*Involves explicitly drawing attention to others' performances to elicit comparisons.*
29	**Plan social support/social change**	*Involves prompting person to plan how to elicit social support from other people.*
30	**Prompt identification as role model/position advocate**	*Involves focusing on how the person may be an example to others and affect their behaviour (e.g. being a good example to children).*

Continued: 40-item CALO-RE Taxonomy continued

	Techniques	Description/Definition
31	**Prompt anticipated regret**	*Involves inducing expectations of future regret about the performance or non-performance of a behaviour.*
32	**Fear arousal**	*Involves presentation of risk and/or mortality information relevant to the behaviour as emotive images designed to evoke fearful response.*
33	**Prompt self talk**	*Encourage the person to use talk to oneself (aloud or silently) before or during behaviours.*
34	**Prompt use of imagery**	*Teach person to imagine successfully performing (or finding it easy to perform) the behaviour.*
35	**Relapse prevention/coping planning**	*This relates to planning how to maintain behaviours that have been changed.*
36	**Stress management/emotional control training**	*This is a set of specific techniques to reduce anxiety and stress to facilitate the performance of the behaviour.*
37	**Motivational interviewing**	*This is a clinical method including a specific set of techniques prompting the person to engage in change talk (includes motivational counselling).*
38	**Time management**	*This includes any technique designed to teach a person how to manage their time.*
39	**General communication skills training**	*This includes any technique directed at general communication skills (e.g., listening, assertive skills).*
40	**Stimulate anticipation of future rewards**	*Create anticipation of future rewards without necessarily reinforcing behaviour throughout the active period of the intervention.*

Source: Michie, van Stralen and West (2011)

Results of Hierarchical Cluster Analysis of Behaviour Change Techniques (16 clusters)

	Cluster	Behaviour Change Techniques
1	**Scheduled consequences**	▪ *Punishment* ▪ *Response cost* ▪ *Chaining* ▪ *Extinction* ▪ *Discrimination training* ▪ *Shaping* ▪ *Negative reinforcement* ▪ *Counter-conditioning* ▪ *Thinning* ▪ *Differential reinforcement*
2	**Reward and threat**	▪ *Social reward* ▪ *Material reward* ▪ *Self-reward* ▪ *Non-specific reward* ▪ *Threat* ▪ *Anticipation of future rewards or removal of punishment* ▪ *Incentive*
3	**Repetition and substitution**	▪ *Behaviour substitution* ▪ *Habit reversal* ▪ *Habit formation* ▪ *Graded tasks* ▪ *Overcorrection* ▪ *Behavioural rehearsal/practice* ▪ *Generalisation of a target behaviour*
4	**Antecedents**	▪ *Restructuring the physical environment* ▪ *Restructuring the social environment* ▪ *Avoidance/changing exposure to cures for the behaviour* ▪ *Distraction*

Source: Michie et al. (2013)

Continued: Results of hierarchical cluster analysis of behaviour change techniques (16 clusters) continued

	Cluster	Behaviour Change Techniques
5	**Associations**	▪ *Discriminative (learned) cue* ▪ *Time out* ▪ *Escape learning* ▪ *Satiation* ▪ *Exposure* ▪ *Classical conditioning* ▪ *Fading* ▪ *Prompts/cues*
6	**Covert learning**	▪ *Vicarious reinforcement* ▪ *Covert sensitisation* ▪ *Covert conditioning*
7	**Natural consequences**	▪ *Health consequences* ▪ *Social and environmental consequences* ▪ *Salience of consequences* ▪ *Emotional consequences* ▪ *Self-assessment of affective consequences* ▪ *Anticipated regret*
8	**Feedback and monitoring**	▪ *Feedback on behaviour* ▪ *Biofeedback* ▪ *Other(s) monitoring with awareness* ▪ *Self-monitoring of outcome of behaviour* ▪ *Self-monitoring of behaviour*
9	**Goals and planning**	▪ *Action planning (including implementation intentions)* ▪ *Problem solving/coping planning* ▪ *Commitment* ▪ *Goal setting (outcome)* ▪ *Behavioural contract* ▪ *Discrepancy between current behaviour and goal standard* ▪ *Goal setting (behaviour)* ▪ *Review behaviour goal(s)* ▪ *Review outcome goal(s)*

Source: Michie et al. (2013)

Continued: Results of hierarchical cluster analysis of behaviour change techniques (16 clusters) continued

	Cluster	Behaviour Change Techniques
10	**Social Support**	▪ *Social support (practical)* ▪ *Social support (general)* ▪ *Social support (emotional)*
11	**Comparison of behaviour**	▪ *Modelling of behaviour* ▪ *Information about others' approval* ▪ *Social comparison*
12	**Self-belief**	▪ *Mental rehearsal of successful performance* ▪ *Self-talk* ▪ *Focus on past success* ▪ *Verbal persuasion to boost self-efficacy*
13	**Comparison of outcomes**	▪ *Persuasive argument* ▪ *Pros and cons* ▪ *Comparative imagining of future outcomes*
14	**Identity**	▪ *Identification of self as role model* ▪ *Self-affirmation* ▪ *Identity associated with changed behaviour* ▪ *Reframing* ▪ *Cognitive dissonance*
15	**Shaping knowledge**	▪ *Reattribution* ▪ *Antecedents* ▪ *Behavioural experiments* ▪ *Instruction on how to perform a behaviour*
16	**Regulation**	▪ *Regulate negative emotions* ▪ *Conserving mental resources* ▪ *Pharmacological support* ▪ *Paradoxical instructions*

Source: Michie et al. (2013)

58 Physical Activity Applications (Middelweerd et al., 2014)

1. RunKeeper 2. Big Welsh Walking Challenge 3. GymPush 4. Hubbub Health 5. My Pocket Coach 6. Sixpack – Personal Trainer 7. Teemo: the fitness adventure game! 8. fitChallenge 9. FitCoach 10. Fitness War 11. Running Club 12. Sworkit Pro 13. Take a Walk Lite 14. Track & Field REALTIMERUN 15. Withings 16. 1 UpFit 17. All-in Fitness 18. Be Fit, Stay Fit Challenge 19. Endomondo Sports Tracker 20. Everywhere Run! 21. Fit Friendzy 22. FitCommit 23. Fitocracy 24. Healthy Heroes 25. Improver 26. Macaw 27. Make your move 28. Nexercise 29. Nike + Running 30. Noom CardioTrainer 31. ShelbyFit 32. SoFit 33. Strava Cycling 34. Tribesports 35. Walk 'n Play 36. 20/20 LifeStyles Online 37. Croi HeartWise 38. Exercise Reminder HD Lite 39. Faster 40. Fitbit Activity Tracker 41. FitRabbit 42. Get Active! 43. Get In Gear 44. Go-go 45. IDoMove 46. Poworkout Trim & Tone	47. SmartExercise 48. CossFitr 49. FitTrack 50. Forty 51. HIIT Interval Training TimerAD 52. Hiking Log 53. Mobile Adventure Walks 54. Run Tracker Pro 55. Running Log! PRO 56. Softrace 57. Activious

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (IPAQ)
(August 2002)
SHORT LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ
The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ
Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation
Translation from English is supported to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information
More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective*. Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarised on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**
   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

   _____ **hours per day**
   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**
_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **weekday**?

_____ **hours per day**
_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participation.

<u>Scoring the IPAQ</u>

1. Low (category 1): This is the lowest level of physical activity. Those individuals who do not meet criteria for categories 2 or 3 (see below) are considered inactive.

2. Moderate (category 2): Any one of the following 3 criteria: 1) 3 or more days of vigorous activity of at least 20 minutes per day OR; 2) 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day OR; 3) 5 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 600 MET-min/week.

3. High (category 3): Any one of the following 2 criteria: 1) Vigorous-intensity activity on at least 3 days and accumulating at least 1500 MET-minutes/week OR; 2) 7 or more days of any combination of walking, moderate-intensity or vigorous intensity activities achieving a minimum of at least 3000 MET-minutes/week

ONLINE SCREENING QUESTIONNAIRE
via SurveyMonkey
(www.surveymonkey.com)

Basic Demographic/Other Information

Q1: Contact Information

First & Last Name
Occupation
Address
City/Town
State/Province
ZIP/Postal Code
Email Address
Phone Number

Q2: Birthdate (MM/DD/YY)

Q3: Age

Q4: Gender

Q5: Can you walk across the room with two legs?

Q6: Can you read and write in English?

Q7: Are you able to access the Internet via a personal computer, laptop, tablet or smartphone on a daily basis?

Q8: Can you commit to participating in a research study for six months plus one additional appointment within one to three months after the six months?

Q9: Are you able to come to the study centre (Preventive Care Clinic at Loma Linda University) for individual appointments at least ten times during the six months study?

Integrated PAR-Q

Q10: Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

Q11: Do you feel pain in your chest when you do physical activity?

Q12: In the past month, have you had chest pain when you were NOT doing physical activity?

Q13: Do you lose your balance because of dizziness or do you ever lose consciousness?

Q14: Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by change in your physical activity?

Q15: Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

Q16: Do you know of any other reason why you should not do physical activity?

Integrated IPAQ

Q17: During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

Days per week: ___

If no vigorous physical activities, please state 'none' and skip to question 19:

Q18: How much time did you usually spend doing vigorous physical activities on one of those days?

Q19: During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? (Do not include walking):

Days per week: ___

If no moderate physical activities, please state 'none' and skip to question 21:

Q20: How much time did you usually spend doing moderate physical activities on one of those days?

Q21: During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

Days per week: ___

If no walking, please state 'none' and skip to number 23:

Q22: How much time did you usually spend walking on one of those days?

Q23: During the last 7 days, how much time did you spend sitting on a weekday?

Hours per week: ___

Q24: Where did you hear about this study?

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

continued on other side...

SAMPLE SIZE CALCULATIONS

Sample size calculation based on min/day in MVPA

2:1 ratio

	Effect size	SDΔ	Actual power	N total	Adjust for dropout
Correlation = 0.7	2	10	0.802	570	814
	2	15	0.800	1170	1671
	2	20	0.800	2124	3034
	5	10	0.803	93	133
	5	15	0.800	189	270
	5	20	0.801	342	489
	10	10	0.837	27	39
	10	15	0.818	51	73
	10	20	0.801	87	124
Correlation = 0.5	2	10	0.800	885	1264
	2	15	0.800	1989	2841
	2	20	0.800	3534	5049
	5	10	0.802	144	206
	5	15	0.801	321	459
	5	20	0.802	570	814
	10	10	0.818	39	56
	10	15	0.812	84	120
	10	20	0.802	144	206
Correlation = 0.4	2	10	0.800	1071	1530
	2	15	0.800	2265	3236
	2	20	0.800	4278	6111
	5	10	0.803	174	249
	5	15	0.803	366	523
	5	20	0.801	687	981
	10	10	0.802	45	64
	10	15	0.803	93	133
	10	20	0.803	174	249
Correlation = 0.2	2	10	0.801	1497	2139
	2	15	0.800	3192	4560
	2	20	0.800	5523	7890
	5	10	0.804	243	347
	5	15	0.801	513	733
	5	20	0.800	885	1264
	10	10	0.809	63	90
	10	15	0.808	132	189
	10	20	0.804	225	321

Dropout rate = 0.300

1:1 ratio

	Effect size	SDΔ	Actual power	N total	Adjust for dropout
Correlation = 0.7	2	10	0.801	506	723
	2	15	0.800	1040	1486
	2	20	0.800	1888	2697
	5	10	0.808	84	120
	5	15	0.805	170	243
	5	20	0.800	304	434
	10	10	0.833	24	34
	10	15	0.804	44	63
	10	20	0.803	78	111
Correlation = 0.5	2	10	0.801	788	1126
	2	15	0.800	1768	2526
	2	20	0.800	3142	4489
	5	10	0.801	128	183
	5	15	0.802	286	409
	5	20	0.801	506	723
	10	10	0.807	34	49
	10	15	0.808	74	106
	10	20	0.801	128	183
Correlation = 0.4	2	10	0.800	952	1360
	2	15	0.800	2012	2874
	2	20	0.800	3802	5431
	5	10	0.800	154	220
	5	15	0.801	324	463
	5	20	0.800	610	871
	10	10	0.820	42	60
	10	15	0.808	84	120
	10	20	0.800	154	220
Correlation = 0.2	2	10	0.800	1330	1900
	2	15	0.800	2836	4051
	2	20	0.800	4908	7011
	5	10	0.803	216	309
	5	15	0.801	456	651
	5	20	0.801	788	1126
	10	10	0.807	56	80
	10	15	0.802	116	166
	10	20	0.804	200	286

Dropout rate = 0.300

Low effect
Med effect
High effect

Recruitment Efforts

WHAT	WHERE	REACHED	WHEN	WHO	CONFIRMED
Facebook Page	Shared on: Personal page Ernie's page HES page Centre's page DrPH Preventive Care page	?	07/09/14	Dominique	YES
Email	To work colleagues: (to have them share with their classes) Rob, Bill, Kim, Cindy, John, Catherine, Harvey, Kim K., Kim P., Javier, Brian, Erica, Roger, Lynn	14 instructors	08/09/14	Dominique	YES
Email	To LSU HR Director to distribute via listserv to all LSU faculty & staff	389	15/09/14	Dominique	YES
Email	To all pastors of SDA churches within the SECC via an email newsletter	Over 200 pastors	15/09/14	Enno	YES
Booth	At Back-to-School bash at Loma Linda University	Approx. 50 people took fliers, approx. 250 walked past the booth	22/09/14	Dominique, Ernie, Daniel	YES
Bulletin Announcement	La Sierra University Church	Approx. 700 church members attend church and would have received a bulletin	27/09/14 (ongoing)	Dominique emailed Chris Oberg	YES
Bulletin Flier/Insert	Loma Linda University Church	Approx. 3500 bulletins were passed out at three different services	04/10/14	Dominique provided 3500 fliers to be inserted into bulletins	YES
Bulletin Announcement	Loma Linda University Church	3500 bulletins are passed out in three different services	11/10; 18/10; 25/10	Dominique confirmed with Joelle	YES

Appendix 4.5: Recruitment efforts continued					
WHAT	**WHERE**	**REACHED**	**WHEN**	**WHO**	**CONFIRMED**
Email	School of Divinity at LSU		15/09/14	School secretary sent out email to all faculty/students in the school	YES
Booth	LSU	gave out fliers to faculty of LSU (approx. 150)	22/09 & 23/09	Dominique	YES
Posters	LSU campus (all over the bulletin boards)	?	15/09/14	Daniel	YES
Posters	LLU School of Public Health/ School of Allied Health	?	15/09/14	Dominique	YES
Posters	LLU Centennial Building	?	15/09/14	Dominique	YES
Posters	LLU Market	?	15/09/14	Dominique	YES
Posters	LLU Campus through Student Activities	?	15/09/14	Dominique	YES
Email	La Sierra Academy sent emails to all their parents about the study	?	15/09/14	Daphne Thomas	YES
Facebook Post	Beyond-U Group	107 members	15/09/14	Devo	YES
Email	School of Religion at LLU sent out an email to all faculty, staff and students	?	09/09/14	Isabel	YES
Article	Association of Schools & Programs of Public Health Friday Letter	?	19/09/14	School of Public Health (Ernie)	YES
Newsletter article	On Campus at LLU	?	25/09/14	Ernie	YES
Email	Redlands Adventist Academy	?	25/09/14	Ernie	YES
Verbal Announcements	LSU classes (undergraduate)		On-going (Sept/Oct)	Dominique	YES
Verbal Announcements	LLU classes		On-going (Sept/Oct)	Keith	YES
Bulletin inserts	Azure Hills Church	Approx. 700 bulletins are stuffed	Oct. 25, 14	Ernie	YES

Appendix 4.5: Recruitment efforts continued					
WHAT	**WHERE**	**REACHED**	**WHEN**	**WHO**	**CONFIRMED**
Community Bulletin	SPH	Faculty/Staff: 317 Email addresses Students: 651 addresses (25% email open-rate among these two groups)	Oct. 6, 14 Oct. 13, 14 Oct. 27, 14 Nov. 3, 14	Ernie (Marcus Chapman)	YES
Email	Redlands Adventist Academy	Staff: 48	Oct. 14, 14	Ernie	YES
Bulletin inserts	Loma Linda Spanish Church	??	??	Ernie	??
Twitter	@llusph @LLUMedSchool @lasierranews @riversidecagov @UCRiverside @U_Calbaptist #research	?	Oct. 16, 14	Dominique	YES
Trading Post	Loma Linda University Newspaper Ad (reaches LLU, the Medical Center and is available at the Loma Linda Market) ($64)	2000 are printed and distributed weekly. Online version has 3000 views per month.	Oct. 31, 14 Nov. 7, 14	Dominique	YES
Verbal Announcement	Azure Hills Young Adult Sabbath School Class	Approx. 70 people	Oct. 25 @ 10:15 a.m.	Dominique	YES
Announcement, Fliers & Posters	General Assembly of Leaders (students) at LLU	Approx. 35 leaders (who took ads back to their respective departments)	Oct. 20 @ 6 p.m.	Dominique	YES
Electronic image of business card & flier	KSGN Community Page (online calendar) Jackie@ksgn.com Jackie Neff	Posted on the 2nd most visited page of website – many people will see it. Announcers talk randomly about events on calendar as well.	Oct. 21, 14 – January, 2015	Dominique	YES

Appendix 4.5: Recruitment efforts continued					
WHAT	**WHERE**	**REACHED**	**WHEN**	**WHO**	**CONFIRMED**
Facebook & Twitter campaign	La Sierra University, LSU schools, church & LLU Health Twitter	?	Oct. 17	Dominique	YES
TV screens at LLU	Loma Linda University	Faculty, staff students at LLU or guests visiting university	Oct. 21, 14 – January 2015	Dominique	YES
Verbal announcement & fliers	Social Work courses at La Sierra University (Daphne, Marni & Jill)	Graduate students in the social work department at LSU	Oct. 27 – 31, 2014	Dominique	YES
Bulletin Inserts	Calimesa SDA Church Fliers	400 bulletins received fliers	Nov. 1, 2014	Dominique	YES
Guest Presentation & Announcement	LLU – DrPH Preventive Care Class	4 DrPH students	Oct. 28, 14	Dominique	YES
Verbal Announcements	LSU graduate courses (Total course announcements: 9 classes)	Approx. 100 – 150 students combined	Nov/Dec. 2014	Dominique	YES
Booth	Loma Linda University Church Young Adults Service	Approx. 200 people	November 15, 2014	Dominique	YES
Feature Speaker University Assembly	La Sierra University Church (inserted recruitment announcement in my presentation)	1300 people	Oct. 21, 14	Dominique	YES
Booth/Table	Redlands Market Night	0 (worthless!)	Nov 20	Dominique	YES
Bulletin Insert	Campus Hill Church	600 people	Nov. 8 & 15	Ernie	YES

Appendix 4.5: Recruitment efforts continued					
WHAT	**WHERE**	**REACHED**	**WHEN**	**WHO**	**CONFIRMED**
Facebook/Twitter	Shared on: Research Personal page Ernie's page	?	04/01/15	Dominique	YES
Email	To LSU HR Director to distribute via listserv to all LSU faculty & staff	389	06/01/15	Dominique	YES
Email	To SDA churches in the SECC	35 churches	04/01/15	Dominique	YES
Bulletin Announcement	La Sierra University Church	Approx. 700 church members that would have received a bulletin	03/01/14 (on-going)	Dominique	YES
Bulletin Announcement	Loma Linda University Church	3500 bulletins are passed out in three different services	17/01 24/01 31/01	Dominique	?
Poster and fliers at desk	Redlands SDA Church	?	?	Ernie	YES (via Shelly Watkins)
Bulletin Inserts	Crosswalk Church	?	?	Dominique	YES (via Tim Gillespie)
Fliers & Announcements	First Service – La Sierra University Church	200	09/01	Samuel Leonor	YES
KSGN Announcement	Radio Station	?	12/01	KSGN	YES
HES Assembly	La Sierra University	30	08/01	Dominique	YES
Fliers & Personal Announcements	La Sierra University (Daniel went around to every staff & faculty office and personally passed out fliers and told people about the study)	Approx. 200	12/01 – 14/01	Daniel	YES
Email	Health Coordinators in SDA churches in IE	?	08/01	Ernie	YES
Announcement	Azure Hills Church Young Adults Section	?	?	Ernie	YES
Article	Community Bulletin – SPH LLU	?	?	Ernie	YES
Fliers & Personal Announcements	Loma Linda University	Approx. 200	15/01/15	Daniel	YES

Appendix 4.5: Recruitment efforts continued					
WHAT	**WHERE**	**REACHED**	**WHEN**	**WHO**	**CONFIRMED**
Lecture/Announcements	La Sierra University Velocity Lunch & Learn Presentation & Announcement of Study	30	15/01/15	Dominique	YES
Email	Azure Hills Young Adult Email Connect Newsletter	?	15/01/15	Pastor Trevan	YES
Facebook	Ernie Medina started a new campaign through his centre's page, groups he manages and personal pages	hundreds	14/01/15	Ernie Medina	YES
Twitter	Dominique used many Loma Linda, Redlands, Riverside and San Bernardino related @'s to reach more entities	?	20/01	Dominique	YES
Email	Ernie sent a special email to all LLU SPH Challenge Participants	30 – 40?	29/01	Ernie	YES
Speaking Engagement	La Sierra University Church	Approx. 400 in audience + online streaming	31/01	Dominique	YES
Research Participant referral cards	All research assistants are giving out 5 referral cards at each appointment in the lab. This has been done since Jan. 1, 2015 and is on-going (no incentives provided)	?	1/1 - on-going	Research Assistants	YES
Facebook	Started another campaign of posting study flier with recruitment text – targeted specific entities and people	?	17/02	Dominique & Ernie	YES
Twitter	Tweeted study flier and added @'s related to Loma Linda and Redlands area as well as LLU and LSU related pages	?	17/02	Dominique	YES
Article	Published via ON CAMPUS at LLU and LLU Med Center (website & newsletter)	?	26/02	Flint	YES
Article	Published via Community Bulletin Newsletter (LLU SPH)	?	23/02	Ernie	YES
Announcement/Fliers	Verbal announcement & fliers distributed at the "Art of Integrative Care" course at LLU	100	05/03	Dominique	YES

Appendix 4.5: Recruitment efforts continued					
WHAT	**WHERE**	**REACHED**	**WHEN**	**WHO**	**CONFIRMED**
Booth, fliers, slides, announcements	A booth for this study was set up at the 2015 Healthy People conference as well as fliers passed out and slides up on screen & verbal announcements from the stage	400	10/03 & 11/03	Dominique & Ernie	YES
Targeted text messages, FB & Twitter push	A number of individual messages sent out to program leaders at the local churches and La Sierra University to ask to disseminate research study information	10 – 20 direct contacts	19/03	Dominique	YES
Research Participants Personal Referral email	An email to all current research participants is sent to request personal referrals for enrolment in the study	66	02/04	Dominique	YES
Fitness Expo (La Sierra)	Table/booth set up	100	19/04	Dominique	YES
Food Fair (La Sierra)	Fliers	300	26/04	Dominique	YES
Lecture/Presentation	Fliers/announcement	100	28/04	Dominique	YES
Announcement to faculty/staff	School of Business, La Sierra University	10 (directly)	29/04	Dominique	YES
Announcement/fliers	Wellness Lunch & Learn, La Sierra University	30	30/04	Dominique	YES
Announcements/fliers	Business Class (La Sierra University)	45	04/05	Dominique	YES
Fliers	Employee Benefits Fair (La Sierra University)	?	11/05	Dominique	YES
Personal Announcements	Research Assistant Daniel visited every academic and administrative office on the campus of La Sierra University to: 1) talk to faculty & staff about the study & qualification criteria 2) ask if they qualify & would like to participate 3) leave fliers & business cards to give to the rest of the department	30 – 40	May 11 - 15	Daniel	YES
Facebook/Twitter	Multiple Times and shared by colleagues at La Sierra and Loma Linda University	?	Last one May 28, 2015	Dominique	YES

RECRUITMENT LETTER/EMAIL

LOMA LINDA UNIVERSITY
School of Public Health

Dear _____,

We are excited to announce open enrollment in a new research study:

THE IMPACT OF GAMEFUL DESIGN ON SEDENTARY ADULTS' MOTIVATION FOR PHYSICAL ACTIVITY AND PHYSICAL ACTIVITY LEVELS

This study is part of the fulfillment of a PhD research study by Dominique Wakefield (PhD student at University of Bath, UK) in collaboration with the Center for Nutrition, Healthy Lifestyles, and Disease Prevention at Loma Linda University.

We are looking for adults between the ages of 25-44, who are currently not physically active.

INCLUSION CRITERIA:

- Ages 25 – 44
- Sedentary (no regular physical activity)
- Willing to participate
- Cleared to participate in physical activity
- Able to read/write in English
- Able to walk with two legs across the room
- Able to access internet daily
- BMI under 40
- Ability to commit for the duration of the study
- Ability to come to the study center at Loma Linda University ten times

other exclusion criteria apply!

REQUIREMENTS:

- Commit to the duration of 6 months + one appointment within 1 – 3 months after
- Come to the study center at Loma Linda University ten times during the study period (appointments made individually to suit schedules)
- Utilize your own electronic device(s) to access the Internet

We would greatly appreciate it, if you shared this information and the attached flier with your department, colleagues, students and personal network!

Thank you very much!

Best regards,

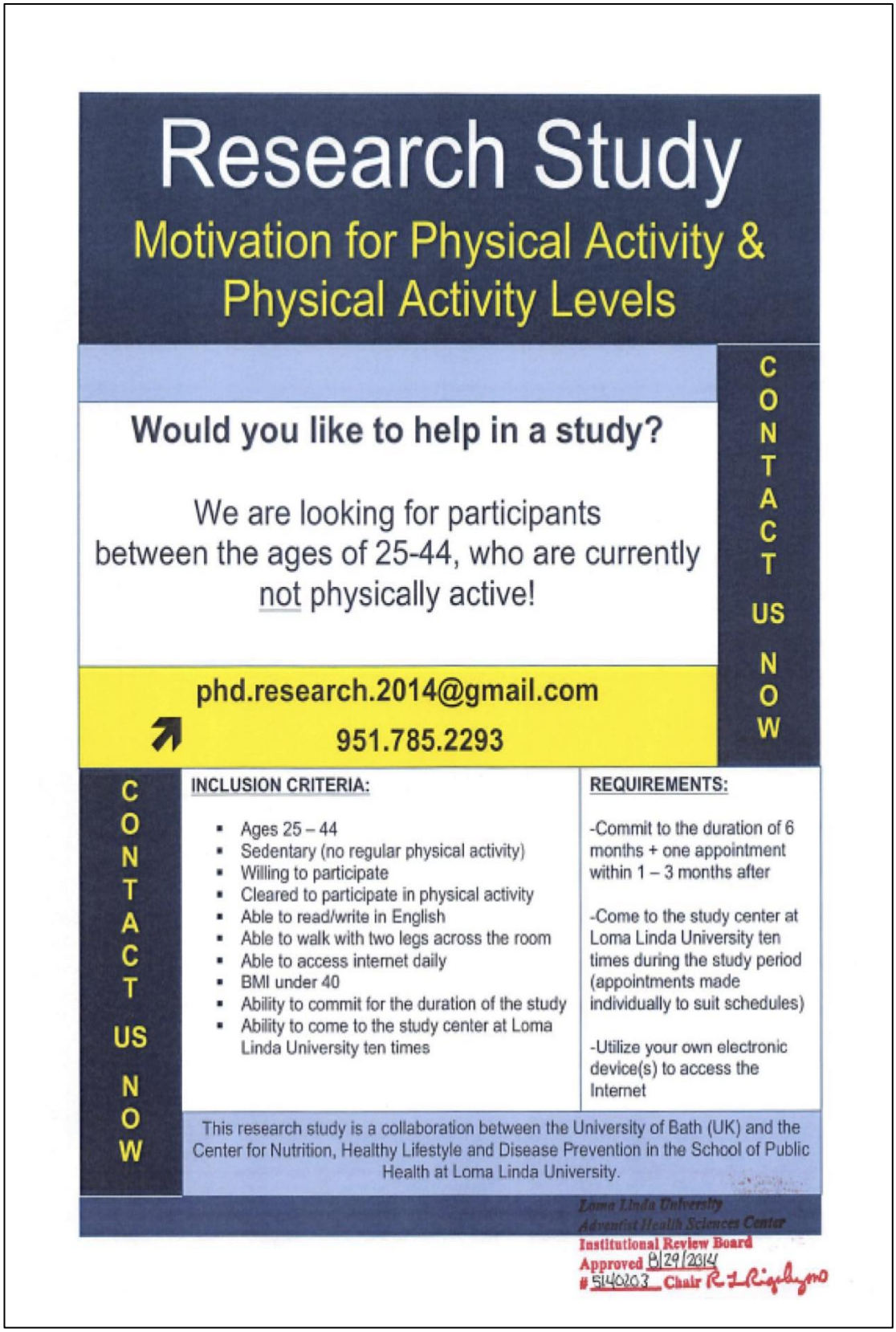
Dominique Wakefield

Dominique Wakefield, PhD (candidate), MA, CPT, CWP

For more information, to enroll in the study or contact:

http://phdresearch2014.webs.com
phd.research.2014@gmail.com
951-785-2293

RECRUITMENT POSTER/FLIER



RECRUITMENT ADVERTISEMENTS
(newspaper, online & bulletin inserts)

EVIDENCE OF RECRUITMENT

EXHIBIT A

Recruitment table at Loma Linda University

EXHIBIT B

ASPPH ASSOCIATION OF SCHOOLS & PROGRAMS OF PUBLIC HEALTH

Connect

Member Research and Reports

Member Research and Reports September 24, 2014

Loma Linda: New Gaming and Physical Activity Study Recruiting

A new research project out of Loma Linda, with co-investigators from Northeastern University (Boston, MA) and University of Bath (UK) entitled "The Impact of Gameful Design on Sedentary Adults' Motivation for Physical Activity and Physical Activity Levels" is being lead by Loma Linda University School of Public Health assistant professor Dr. Ernesto Medina, and Ms. Dominique Wakefield, a PhD candidate at the University of Bath and assistant professor at La Sierra University (La Sierra, CA).

[Photo: Dr. Ernesto Medina]

"The concept of gamification has shown potential for increasing user engagement, user activity, user productivity and social interactions; however, many gamefully designed activity tools have not been properly

EXHIBIT C

the bunch! Text or call (909) 705-9072. Oct31

FURNISHED ROOM for rent near LLU. Female student or intern preferred. Wi-Fi, cable, washer / dryer. Share common area plus bathroom. Clean and quiet. Call Beverly (323) 459-9610. Nov14

ONLY LLU female student. Room $475. Spacious, rooming with only one LLU student. Laundry facilities. Private parking. Excellent quiet neighborhood. Three minutes to LLU. No pets. (604) 329-1908. Oct31

I AM LOOKING for a fifty-year-old or plus female to rent a furnished or unfurnished room. The woman must be clean, neat, and considerate. No smoking, drinking or having parties. I am within walking distance to the Medical Center. Access to internet is available. $400 includes the utilities. Call (909) 213-1990. Nov21

ROOM FOR RENT very close to LLUMC. Share three bedroom, two bathroom house with brother and sister. No smoking or drugs. New carpet and paint. $500 per month plus deposit. Call Jay Harris (951) 505-8774. Nov7

QUIET EAST HIGHLAND neighborhood: Single detached room for rent with a private entrance. Perfect for a hard working student. New carpet, freshly painted, full private bathroom and walk in closet. Accessibility to an enclosed courtyard. Includes utilities, Wi-Fi, DirecTV. Female renter only. Contact Suzie at (909) 801-4758 or <swhitego@gmail.com>. Nov21

LOMA LINDA TOWNHOUSE. Clean, studious roommate wanted. One room for rent with shared bathroom. No smoking or pets. Recently remodeled. Pools and tennis. Washer / dryer, two-car garage, central air conditioning. Private backyard; yard work included. Two miles to LLUMC. $550 a month plus deposit and splitting utilities. Available January. (616) 540-8470. Oct31

LOOKING FOR SINGLE medical student or resident to rent a room. Two rooms available. $500 each. Must have own transportation. Call Efren or Edna at (909) 856-0797, (909) 213-6667 or (909) 824-5300. Nov14

MALE ROOMMATE wanted. Loma Linda house. Great for students. Rent, $400 plus utilities ($40). Call or text Kay at (559) 430-5280. No pets. Nov14

FURNISHED ROOM for rent for a student or a single hospital employee, with no pets. Separate entrance, SDA preferred. $525 a month. Utilities included. Call (909) 799-3046. Nov21

FURNISHED ROOM for rent, one mile from LLUMC, south of Lawton. Includes utilities, kitchen and laundry privileges, and Wi-Fi. $500 a month. (909) 796-6838. Oct31

LOOKING FOR ONE female roommate to join two female residents at beautiful home in one of nicest neighborhoods in Loma Linda. Washer / dryer, refrigerator / freezer, stove, oven, microwave, garage, shared living space, and spacious yard all included. Rent is $625 plus one-third of utilities. Contact Lucy Lewis at (319) 321-1380 or <LaMariposa17@gmail.com>. NCFNS. Oct31

Houses

LLU STUDENTS! We have studios, one, two, and three bedroom apartments and or houses for rent. If you are a current or incoming student of Loma Linda University, please call us to find out what we have available for you to rent. No pet policy enforced. LLU Rental Office (909) 558-4374. Inst

CUTE AND COZY, two bedroom, one bathroom home with fenced yard in Loma Linda. Large sunroom and new renovated bathroom and kitchen, walk to work or school, one block from LLU, perfect for young couple. $1,250 a month, plus deposit. Pets welcome with deposit. Available mid-October, call for appointment. (707) 321-0622. Oct11

LOMA LINDA. Four bedrooms, three bathrooms, and attached two-car garage. Newly renovated and move-in ready. $1,750 monthly plus one month deposit. Please call (909) 557-3872. Oct31

SMALL FURNISHED, one bedroom, one bathroom house. Covered patio, small fenced yard. $600 a month. Mentone. (909) 794-8669. Dec31

RECHE CANYON. Rural area. Rear house, two bedrooms, and one bathroom. All utilities paid. $1,295 monthly plus security deposit. Washer / dryer hookups. Cute home. (909) 289-1880. Oct31

TWO BEDROOMS, one bathroom, two-car garage, fenced yard, new paint and carpet. Pets on approval. This is a nice home on a tree-lined street in a good area of San Bernardino, close to hospital, freeway and school. 15 minutes from LLUH. $1,150 plus security. (909) 693-8426. Nov7

HOUSE FOR RENT, available November 1, 2014. Two bedrooms, one bathrooms, refrigerator, washer / dryer, walking distance from LLUMC, off-street parking. No pets, no smoking. Trash, water, yard work paid by owner. Rent $1,100, deposit $1,100. Call Greta (626) 484-6235. Nov7

HOUSE FOR RENT, available November 1, 2014. One bedroom, one bathroom, newly renovated, refrigerator, washer / dryer, walking distance from LLUMC, garage. No pets, no smoking. Trash, water, and yard work paid by owner. Rent $1,050, deposit $1,050. Call Greta (626) 484-6235. Nov7

HIGHLAND HOME for rent. Three bedrooms, two bathrooms, three-car garage. $1,600. Includes water and gardener. No smoking, pets okay. Contact Denise at <2fivebs@sbcglobal.net>. Oct31

HOUSE FOR RENT, available now. Three bedrooms, two bathrooms, central air, fenced yard, two-car garage, near Mission Road. Good school district. $1,500 a month for rent plus deposit. Call (909) 363-6999, for information. Nov7

GRAND TERRACE townhouse for rent, near Loma Linda and Colton. 1,427 square feet, three bedrooms, three bathrooms. Quite and well kept gated community with pool / Jacuzzi and workout room. Attached two-car garage, new blinds, fresh painted throughout, washer / dryer hookups in garage. No Pets, no Smokers. Clean and ready to rent. (No phone number provided). Oct31

A BEAUTIFUL AND newly refurbished Condo. Quiet and gated condo complex. Hardwood floors downstairs. Stainless steel kitchen appliances. Washer / dryer in unit. Walk in master bedroom closet. Two-car attached garage. Pool, spa, fitness room. Close to Highway 10 and LLU. Flagstone private patio. Available now. Call (949) 503-3949 or email <pwertz@blackdotwireless.com>. Nov14

COOLEY RANCH HOME, two bedrooms, one bathroom. Attached two-car garage, washer / dryer hookup. Fenced backyard. Clean and well maintained. Five minutes west of LLUMC. Shopping two blocks away. No smoking. $1,100 per month plus deposit, small pets extra. (909) 215-7978. Available November 1. Oct31

HIGHLAND house for rent. Four bedrooms, two bathrooms, new kitchen and flooring. Clean area. $1,450 per month. For more information, call (909) 855-9501 or (217) 341-8610. Oct31

TWO-MINUTE WALKING distance to LLUMC. Nice south of Barton Road. There bedroom home with central air conditioning, two bathrooms, fireplace, and two-car garage. Nice patios. $1,500 a month plus security deposit; one-year lease, at least. No pets or smoking. Available now. Call (909) 478-9640. NCFNS. Thank you. Oct31

THREE BEDROOMS, two bathrooms, fruit trees. Walk zone to LLU. $1,800 a month. Harwood floors, flagstone patio. (951) 218-9292. Oct31

LOMA LINDA HOUSE for lease. Four bedrooms, three bathrooms, 2,200 square feet. Nice house. $2,100 deposit. 11635 Wiley Street, Loma Linda 92354. (909) 435-8677. Nov7

REDLANDS. House for rent, 26985 Beaumont Avenue. $1,600 a month. Three bedrooms, two bathrooms, fireplace, two-car garage, washer / dryer hookups, new carpet, fans, doors, kitchen, bathrooms, large yard. Quiet, on one acre. John at (909) 362-0669. Nov14

LOMA LINDA modern home on Mission. 2,800 square feet, one-story spacious home, three large bedrooms, three bathrooms, office room, open kitchen with island; large family, living, dining and laundry rooms. Master bedroom, walk-in closet, separate shower, oversized tub, two sinks. Wood tile flooring, high ceilings, and three-car garage. Safe and two miles to LLUMC. Tennis, basketball, playground. $2,200. (951) 217-2793. Nov14

UNITED PROPERTY MANAGEMENT. Houses, apartments, condos and studios available! Loma Linda, Redlands, Colton. Call (909) 796-2897 to view any of our available rentals. Go to <www.united-pm.com> for a full updated list of homes available today! Oct31

LOMA LINDA. Three bedrooms, 2.5 bathrooms. Veach Street. Beautiful, spacious home with large community pool and parks. All kitchen appliances and washer / dryer included. $1,975 per month. (909) 796-2897. <www.united-pm.com>. Oct31

SAN BERNARDINO. Two

EXHIBIT D

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LOMA LINDA UNIVERSITY
School of Public Health
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Monday, October 27, 2014

- What Will Your Verse Be? • Public Health Blog
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- Loma Linda Study Finds Determinants of Substance Use among Hispanic Adults

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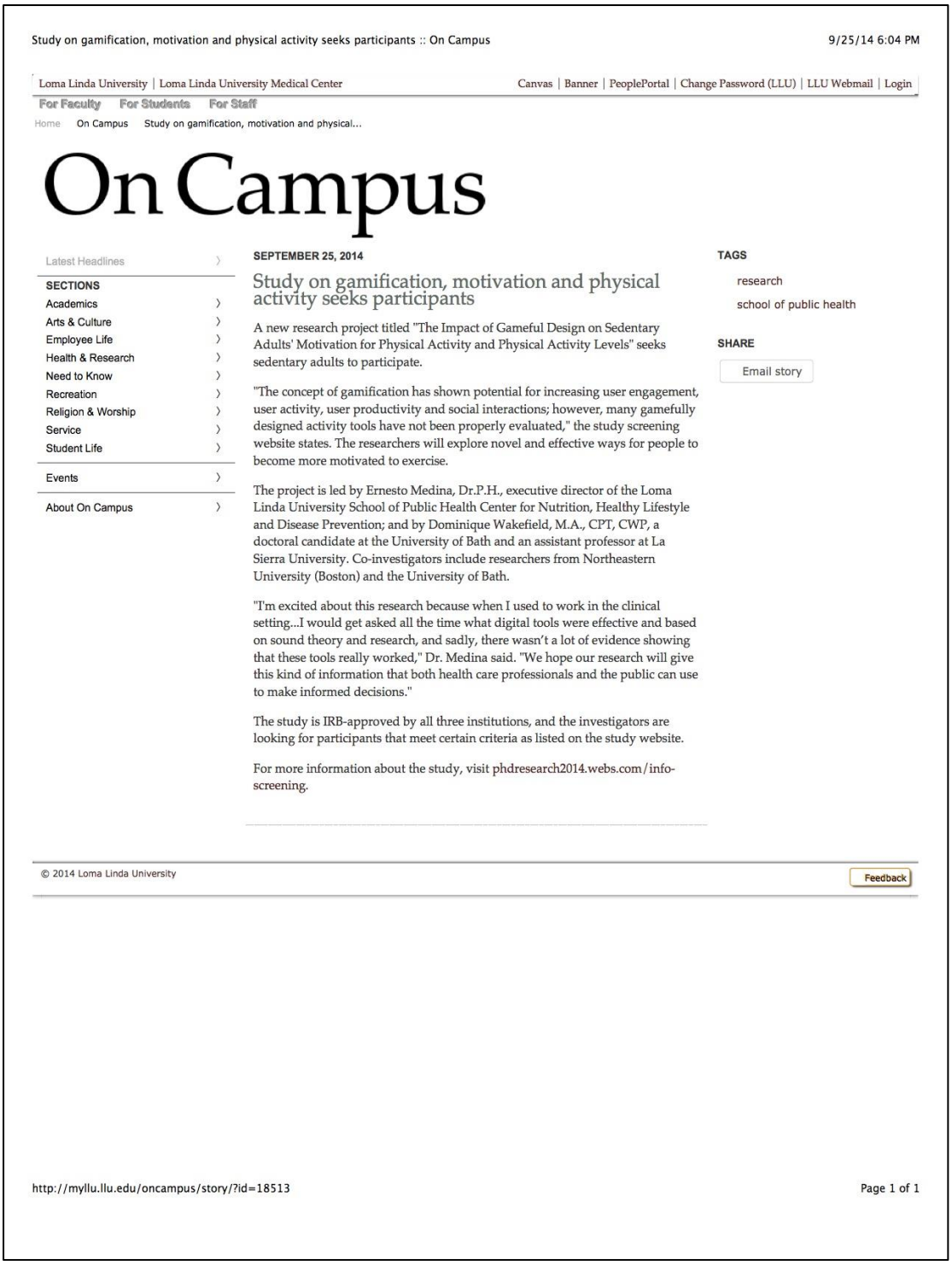
The Master's International program provides Loma Linda University School of Public Health students with the opportunity of complementing a master's degree in public health

Volunteer to Participate in a Research Study – *The Impact of Gameful Design on Sedentary Adults' Motivation for Physical Activity and Physical Activity Levels* We are looking for

The National Academies is pleased to announce a call for nominations and applications for the **2015 Jefferson Science Fellows program**. The fellowship is open to tenured, or

EXHIBIT E



Study on gamification, motivation and physical activity seeks participants :: On Campus 9/25/14 6:04 PM

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For Faculty For Students For Staff

Home On Campus Study on gamification, motivation and physical...

On Campus

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SEPTEMBER 25, 2014

Study on gamification, motivation and physical activity seeks participants

A new research project titled "The Impact of Gameful Design on Sedentary Adults' Motivation for Physical Activity and Physical Activity Levels" seeks sedentary adults to participate.

"The concept of gamification has shown potential for increasing user engagement, user activity, user productivity and social interactions; however, many gamefully designed activity tools have not been properly evaluated," the study screening website states. The researchers will explore novel and effective ways for people to become more motivated to exercise.

The project is led by Ernesto Medina, Dr.P.H., executive director of the Loma Linda University School of Public Health Center for Nutrition, Healthy Lifestyle and Disease Prevention; and by Dominique Wakefield, M.A., CPT, CWP, a doctoral candidate at the University of Bath and an assistant professor at La Sierra University. Co-investigators include researchers from Northeastern University (Boston) and the University of Bath.

"I'm excited about this research because when I used to work in the clinical setting...I would get asked all the time what digital tools were effective and based on sound theory and research, and sadly, there wasn't a lot of evidence showing that these tools really worked," Dr. Medina said. "We hope our research will give this kind of information that both health care professionals and the public can use to make informed decisions."

The study is IRB-approved by all three institutions, and the investigators are looking for participants that meet certain criteria as listed on the study website.

For more information about the study, visit phdresearch2014.webs.com/info-screening.

TAGS

research
school of public health

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Email story

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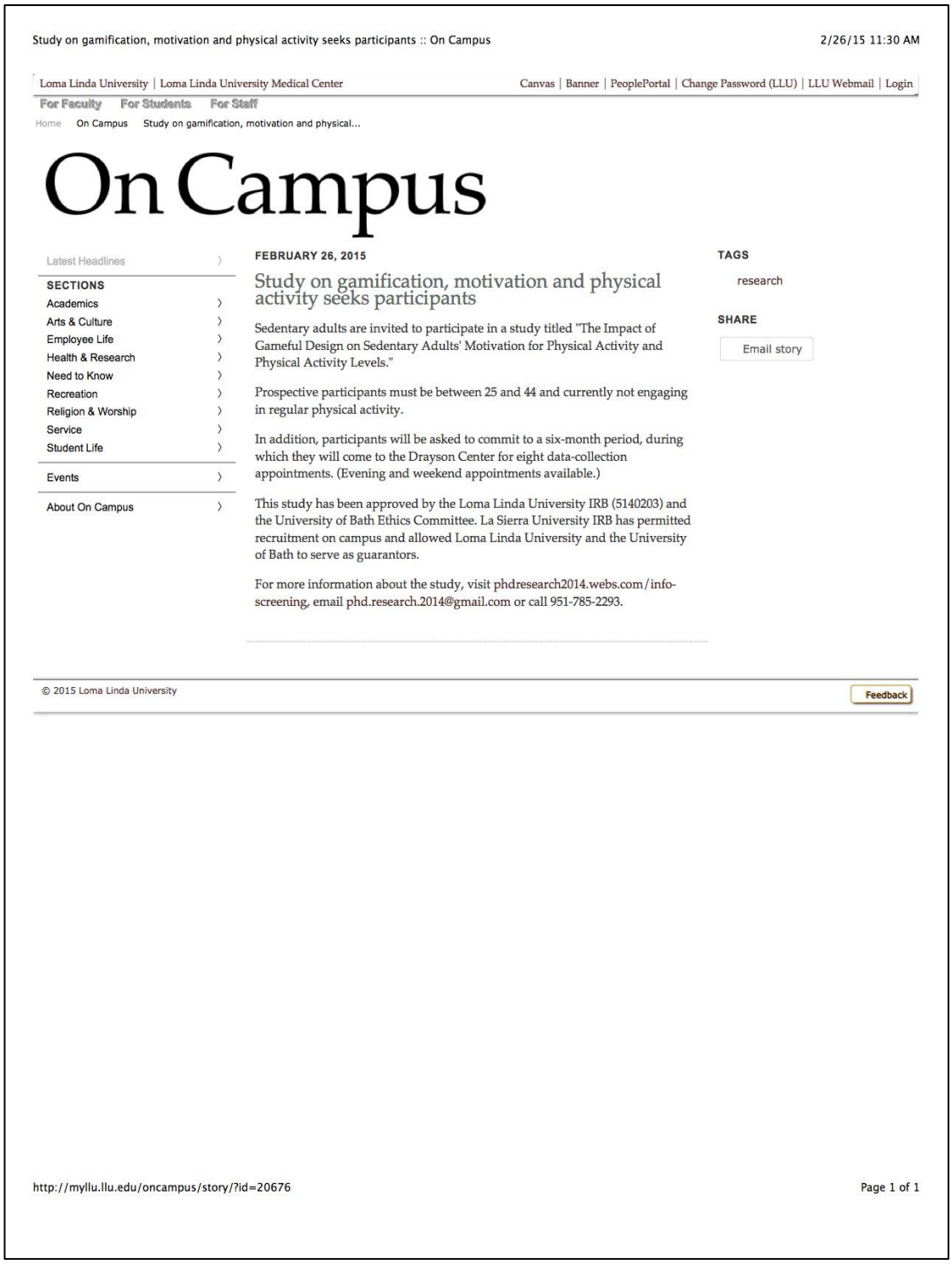
http://myllu.llu.edu/oncampus/story/?id=18513 Page 1 of 1

EXHIBIT F



Study on gamification, motivation and physical activity seeks participants :: On Campus 2/26/15 11:30 AM

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For Faculty For Students For Staff

Home On Campus Study on gamification, motivation and physical...

On Campus

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FEBRUARY 26, 2015

Study on gamification, motivation and physical activity seeks participants

Sedentary adults are invited to participate in a study titled "The Impact of Gameful Design on Sedentary Adults' Motivation for Physical Activity and Physical Activity Levels."

Prospective participants must be between 25 and 44 and currently not engaging in regular physical activity.

In addition, participants will be asked to commit to a six-month period, during which they will come to the Drayson Center for eight data-collection appointments. (Evening and weekend appointments available.)

This study has been approved by the Loma Linda University IRB (5140203) and the University of Bath Ethics Committee. La Sierra University IRB has permitted recruitment on campus and allowed Loma Linda University and the University of Bath to serve as guarantors.

For more information about the study, visit phdresearch2014.webs.com/info-screening, email phd.research.2014@gmail.com or call 951-785-2293.

TAGS

research

SHARE

Email story

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EXHIBIT G

Downtown Redlands Market Night Application

1. Name of Business or Group: Loma Linda University (Center for Nutrition, Healthy Lifestyles & Disease Prevention)

2. Contact Person: Dominique Wakefield

3. Driver License Number or State Issued Identification Number: B7974372 State: CA

4. Address: 41691 Sierra Vista Ave #207 (Street) Riverside (City) CA 92505 (Zip)

5. Telephone: 269-605-3595 (Day) / (Evening) Fax: /

6. Email: dominique.wakefield@gmail.com Website: phdresearch2014.webs.com

7. These permits are needed **after approval**:

State Board of Equalization Permit No. N/A

Redlands Business License No. N/A Exp. Date

I don't have these?

8. Items to be sold or distributed, choose one category **(please include photos &/or brochure)**:

_____Antiques/Collectibles	_____Clothing	_____Food	✓Fliers
_____Gifts/Specialty Items	_____Hand Crafts/Art	_____Household Items	✓mints
_____Jewelry	_____Kitchen Items	_____Personal Items	

List all items for sale **(items not listed cannot be sold)**: N/A

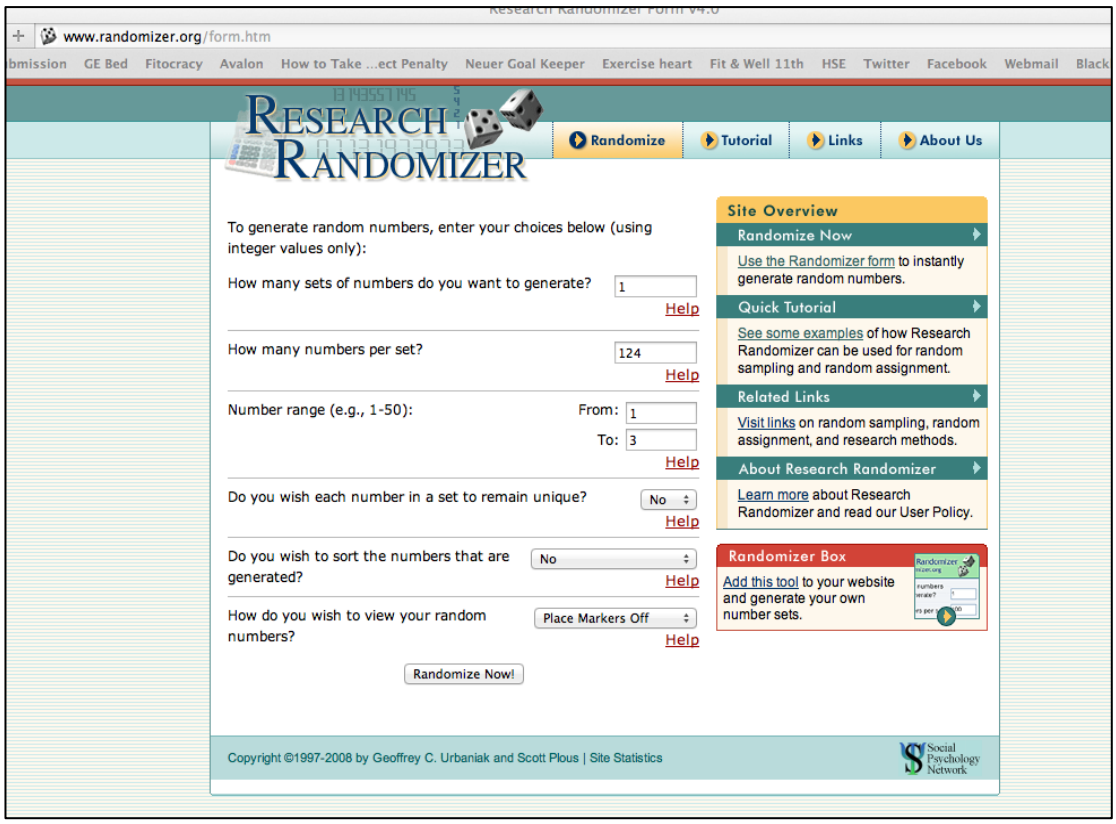
9. Vehicle or trailer used in display or sales: Yes _____ No ✓ Size of vehicle/trailer: _____

10. **Other** Vendor Types not listed above:

_____Business Promotions	_____Nonprofit (I.D. #_____)
✓Information/Educational	_____"Downtown business" (See rule 15, page 4)

Describe the nature of your activity: Recruitment for a new research study conducted at Loma Linda University. The study focuses on motivation for physical activity & increasing physical activity and we need to recruit people to voluntarily participate. See website above for more details. We would simply talk to people, hand out fliers and do free blood pressure checks!

RESEARCH RANDOMIZER
(www.randomizer.org)



NOTE:
Numbers 1 and 2 were allotted for intervention group and number 3 was allotted for control group to generate a 2:1 ratio.

ENROLMENT DATA

(white = intervention group; yellow = control group; red = dropout)

Research Randomizer Results: 08.10.2014
1 Set of 124 Non-unique Numbers Per Set
Range: From 1 to 3 -- Unsorted

Set 1	Subject #	ID (mm/dd/yy)	Age	M/F	Dropout reason
2	1	092883INT	30	F	Screening error: BMI over 40
3	2	92877	36	F	
3	3	40778	36	M	
2	4	051170INT	44	F	
3	5	52475	39	F	Screening error: BMI over 40
1	6	100275INT	38	F	
1	7	021682INT	32	M	
1	8	041985INT	29	M	
2	9	012180INT	34	F	
1	10	103083INT	30	F	Did not provide reason
2	11	090587INT	27	F	Did not provide reason
2	12	050781INT	33	M	Screening error: BMI over 40
2	13	080475INT	39	F	
1	14	100385INT	28	M	Broke his leg
3	15	103172	42	F	
3	16	100678	35	F	
3	17	52479	35	M	
1	18	042374INT	40	F	
2	19	080181INT	33	F	Due to time constraints
1	20	051489INT	25	F	
1	21	092888INT	26	M	Screening error: BMI over 40
3	22	80987	27	M	
2	23	070789INT	25	F	
1	24	052078INT	36	F	Tore three ligaments in Dec.
2	25	091072INT	42	F	
1	26	120587INT	26	F	
1	27	080388INT	26	F	
1	28	122470INT	43	F	
2	29	072378INT	36	M	
3	30	82871	43	F	
3	31	32087	27	F	
1	32	092082INT	32	F	Screening error: BMI over 40
3	33	12083	31	F	
3	34	111185	28	F	
1	35	062581INT	33	F	
1	36	060774INT	40	M	
3	37	91783	31	M	
3	38	71282	32	F	MOVING
2	39	041085INT	29	F	
1	40	050175INT	39	M	
2	41	011689INT	25	F	Screening error: BMI over 40
2	42	101673INT	41	F	

3	43 122170	43	F		
3	44 51883	31	F		
2	45 021789INT	25	F		
2	46 100370INT	44	F		
2	47 071776INT	38	M		
3	48 72379	35	M		
3	49 21185	29	M		
1	50 082983INT	31	F		
3	51 111372	42	F		
2	52 081775INT	39	F		
1	53 080476INT	38	F		
2	54 011671INT	43	F		
3	55 41589	25	F		
1	56 041770INT	44	M		
2	57 041183INT	31	F		
3	58 101189	25	F		
2	59 091487INT	27	M		
2	60 070779INT	35	F		
1	61 072289INT	25	F		
2	62 033181INT	33	F		
1	63 061589INT	25	F		
3	64 100289	25	F		
1	65 121371INT	43	F		
3	66 122084	30	F	X	Personal reasons
2	67 030484INT	30	F		
1	68 080181INT	33	M		
1	69 071076INT	38	M		
1	70 041284INT	30	F	X	Did not provide a reason
3	71 61985	29	F		
1	72 091970INT	44	F		
3	73 61977	37	M		
3	74 63087	27	F		
2	75 010877INT	38	M		
2	76 042689INT	25	F		
3	77 80271	43	F		
3	78 31674	41	M		
3	79 82175	39	M		
1	80 090777INT	37	F		
3	81 071383INT	31	F		
2	82 092689INT	25	M	X	Overcommitted
2	83 012085INT	30	M		

SUMMARY

Total enrolment = 83 (55 intervention, 28 control) (25 males, 58 females)

⇒ Average age: 33.56

Total dropouts = 15 (12 intervention, 3 control) (4 males, 11 females)

⇒ Average age: 30.4

Total enrolment to completion = 68 (43 intervention, 25 control) (21 males, 47 females)

⇒ Average age: 34.26

BIOMETRIC DATA RECORDING SHEET

Biometric Data Recording Sheet

Participant Number: _____

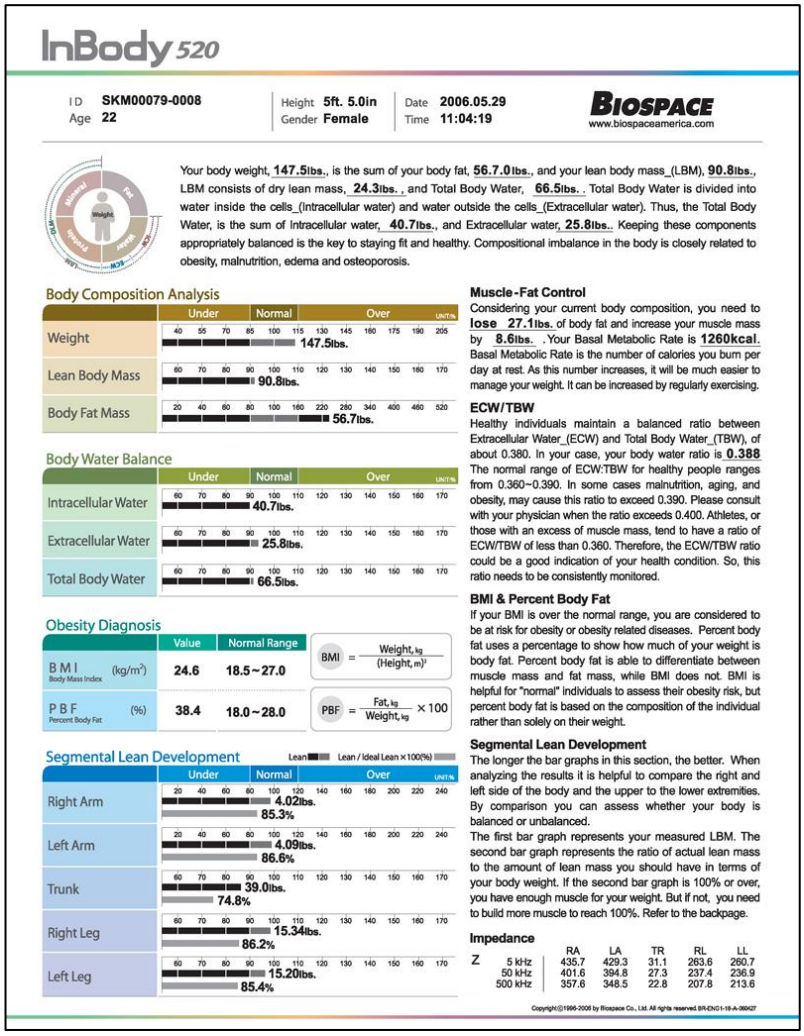
Date: _____

Birthdate: ____/____/____ M F

	Height	Weight	BMI	Body Fat %	Research Team Member Name
Baseline **Date: _____**					
Post-Intervention: **Date: _____**					
3-months follow-up **Date: _____**					
6-months follow-up: **Date: _____**					

BIOMETRIC DATA COLLECTION EQUIPMENT: InBody 520

Sample data printout:



InBody 520

ID SKM00079-0008
Age 22

Height 5ft. 5.0in
Gender Female

Date 2006.05.29
Time 11:04:19

BIOSPACE
www.biospaceamerica.com

Your body weight, 147.5lbs., is the sum of your body fat, 56.7.0lbs., and your lean body mass_(LBM), 90.8lbs., LBM consists of dry lean mass, 24.3lbs. , and Total Body Water, 66.5lbs. . Total Body Water is divided into water inside the cells_(Intracellular water) and water outside the cells_(Extracellular water). Thus, the Total Body Water, is the sum of Intracellular water, 40.7lbs., and Extracellular water, 25.8lbs.. Keeping these components appropriately balanced is the key to staying fit and healthy. Compositional imbalance in the body is closely related to obesity, malnutrition, edema and osteoporosis.

Body Composition Analysis

	Under	Normal	Over
Weight		147.5lbs.	
Lean Body Mass		90.8lbs.	
Body Fat Mass		56.7lbs.	

Body Water Balance

	Under	Normal	Over
Intracellular Water		40.7lbs.	
Extracellular Water		25.8lbs.	
Total Body Water		66.5lbs.	

Obesity Diagnosis

	Value	Normal Range
BMI (kg/m²) Body Mass Index	24.6	18.5~27.0
PBF (%) Percent Body Fat	38.4	18.0~28.0

BMI = Weight, kg / (Height, m)²

PBF = Fat, kg / Weight, kg × 100

Segmental Lean Development

Lean / Lean / Ideal Lean × 100(%)

	Under	Normal	Over
Right Arm		4.02lbs. 85.3%	
Left Arm		4.09lbs. 86.6%	
Trunk		39.0lbs. 74.8%	
Right Leg		15.34lbs. 86.2%	
Left Leg		15.20lbs. 85.4%	

Muscle-Fat Control

Considering your current body composition, you need to lose 27.1lbs. of body fat and increase your muscle mass by 8.6lbs. . Your Basal Metabolic Rate is 1260kcal. Basal Metabolic Rate is the number of calories you burn per day at rest. As this number increases, it will be much easier to manage your weight. It can be increased by regularly exercising.

ECW/TBW

Healthy individuals maintain a balanced ratio between Extracellular Water_(ECW) and Total Body Water_(TBW), of about 0.380. In your case, your body water ratio is 0.388 The normal range of ECW:TBW for healthy people ranges from 0.360~0.390. In some cases malnutrition, aging, and obesity, may cause this ratio to exceed 0.390. Please consult with your physician when the ratio exceeds 0.400. Athletes, or those with an excess of muscle mass, tend to have a ratio of ECW/TBW of less than 0.360. Therefore, the ECW/TBW ratio could be a good indication of your health condition. So, this ratio needs to be consistently monitored.

BMI & Percent Body Fat

If your BMI is over the normal range, you are considered to be at risk for obesity or obesity related diseases. Percent body fat uses a percentage to show how much of your weight is body fat. Percent body fat is able to differentiate between muscle mass and fat mass, while BMI does not. BMI is helpful for "normal" individuals to assess their obesity risk, but percent body fat is based on the composition of the individual rather than solely on their weight.

Segmental Lean Development

The longer the bar graphs in this section, the better. When analyzing the results it is helpful to compare the right and left side of the body and the upper to the lower extremities. By comparison you can assess whether your body is balanced or unbalanced.
The first bar graph represents your measured LBM. The second bar graph represents the ratio of actual lean mass to the amount of lean mass you should have in terms of your body weight. If the second bar graph is 100% or over, you have enough muscle for your weight. But if not, you need to build more muscle to reach 100%. Refer to the backpage.

Impedance

Z	RA	LA	TR	RL	LL
5 kHz	435.7	429.3	31.1	263.6	260.7
50 kHz	401.6	394.8	27.3	237.4	236.9
500 kHz	357.6	348.5	22.8	207.8	213.6

ACCELEROMETER DEVICE: GENEACTIV

"GENEActiv is a reliable body-worn accelerometer that measures and tracks everyday living in all environments. This leading, technical design offers 0.5Gb of raw data in an open format and comes as a unique, fully waterproof, value for money instrument with 2 months of battery life"
(http://www.geneactiv.org/wp-content/uploads/2014/03/geneactiv_instruction_manual_v1.2.pdf)

Device details:

- 43mm x 40mm x 13mm (size)
- 16g (without strap) (weight)
- PC/ABS (medical device grade)
- PC (medical device grade)
- Gold-plated (data contact material)
- 20mm heavy-duty spring bar (fixings)
- PU resin (strap)
- Rechargeable lithium polymer (battery type)
- Water-resistant to 10m (IP67-1m25hrs)
- Dust tight (IP67)
- 5 – 40 deg C (operating temperature)
- 0.5m drop resistant (mechanical impact)
- 0.5Gb non-volatile (memory)
- Selectable 10-100Hz (logging frequencies)
- 45 days @ 10Hz, 7 days @ 100Hz (maximum logging periods)
- Quartz real-time clock (type)
- MEMS (sensor type for acceleration measurement)
- +/- 8g (range for acceleration measurement)
- 12 bit (3.9 mg) (resolution for acceleration measurement)
- Silicon photodiode (sensor type for light measurement)
- 400 to 1100 nm (wavelength for light measurement)
- 0 – 3000 Lux typical (range for light measurement)
- 5 Lux typical (resolution for light measurement)
- +/- 10% @ 1000 Lux calibration (accuracy for light measurement)
- Mechanical membrane switch (sensor type for event logger)
- Linear active thermistor (sensor type for temperature measurements)
- 0 to 60 deg C (range for temperature measurements)
- 0.25 deg C (resolution for temperature measurements)
- +/- 1 deg C (accuracy for temperature measurements)
- Every 30s minimum (measurement frequency for temperature measurements)

System requirements:

- PC with Intel P4 Processor, 2Gb Memory
- Windows XP, Vista or 7
- .net Framework 3.5

Validation Study of GENEActiv Accelerometers:
Esliger, D.W., Rowlands, A.V., Hurst, T.L., Catt, M., Murray, P., and Eston, R.G., 2011. Validation of the GENEActiv accelerometer. *Medicine & Science in Sports & Exerc*ise, 43(6), pp. 1089–1093.

Conclusion: *"The GENEActiv is a reliable and valid measurement tool capable of classifying the intensity of physical activity in adults"* (Esliger et al., 2011).

BEHAVIOURAL REGULATIONS IN EXERCISE QUESTIONNAIRE (BREQ-2)

The BREQ-2 is measurement tool of the continuum of self-determination. Scoring can be multidimensional (separate sub-scale scores) or unidimensional (relative autonomy index) of the degree of self-determination (Ryan & Connell, 1989).

Multidimensional Scoring

Calculation of mean scores for each set of items.

Amotivation	5	9	12	19
External regulation	1	6	11	16
Introjected regulation	2	7	13	
Identified regulation	3	8	14	17
Intrinsic regulation	4	10	15	18

Relative Autonomy Index (RAI)

"The relative autonomy index (RAI) is a single score derived from the subscales that gives an index of the degree to which respondents feel self-determined. The index is obtained by applying a weighting to each subscale and then summing these weighted scores. In other words, each subscale score is multiplied by its weighting and then these weighted scores are summed.

Computation of an RAI for the BREQ-2 is a little more problematic as it comprises an odd number of subscales. For the time being, I recommend applying the following weightings, bearing in mind the need for further research to establish the best way to weight these scales." (Markland, 2000)

Amotivation	-3
External regulation	-2
Introjected regulation	-1
Identified regulation	+2
Intrinsic regulation	+3

Actual BREQ-2 Questionnaire

Age: _____ years Sex: male female (please circle)

WHY DO YOU ENGAGE IN EXERCISE?

We are interested in the reasons underlying people's decisions to engage, or not engage in physical exercise. Using the scale below, please indicate to what extent each of the following items is true for you.

		Not true For me		**Sometimes true for me**		**Very true for me**
1	I exercise because other people say I should	0	1	2	3	4
2	I feel guilty when I don't exercise	0	1	2	3	4
3	I value the benefits of exercise	0	1	2	3	4
4	I exercise because it's fun	0	1	2	3	4
5	I don't see why I should have to exercise	0	1	2	3	4

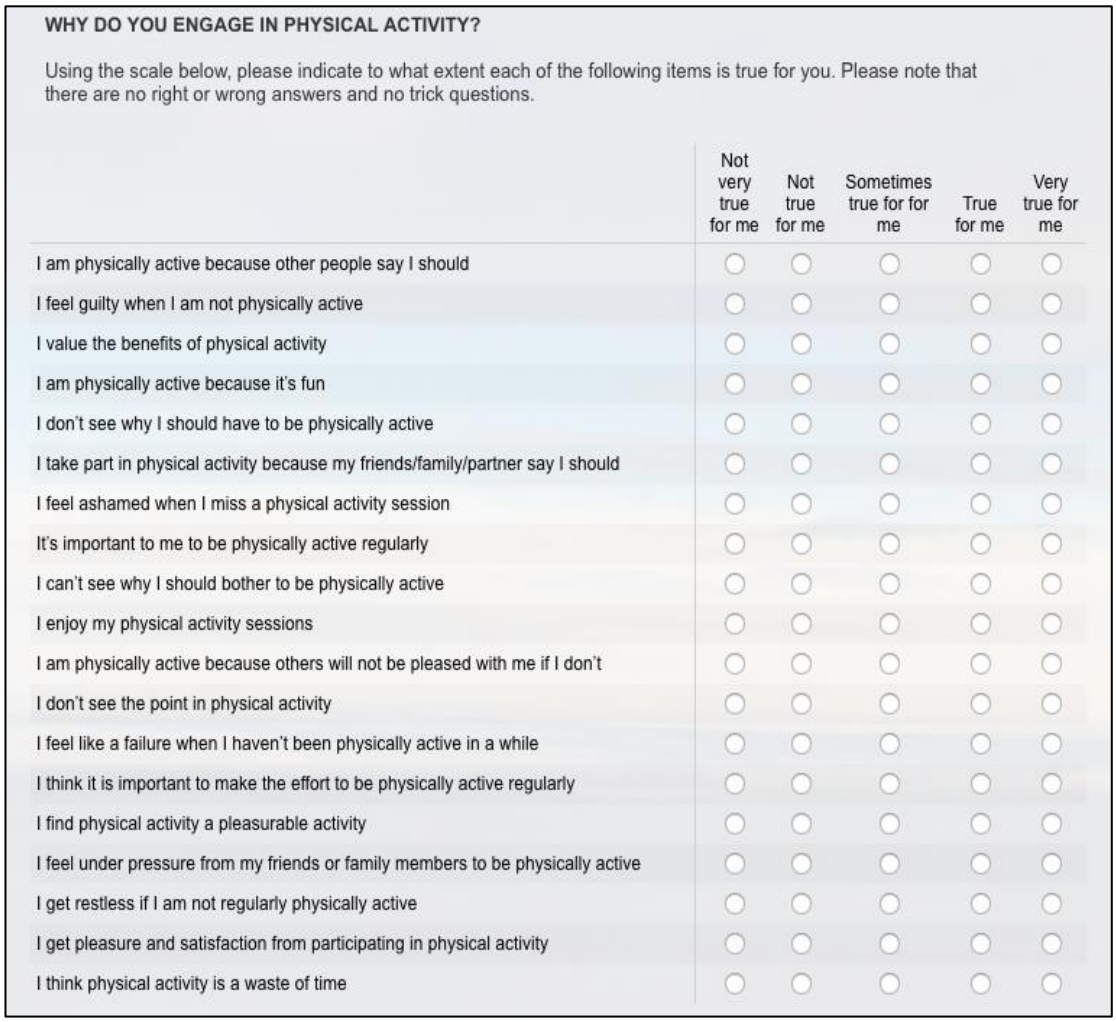
6	I take part in exercise because my friends/family/partner say I should	0	1	2	3	4
7	I feel ashamed when I miss an exercise session	0	1	2	3	4
8	It's important to me to exercise regularly	0	1	2	3	4
9	I can't see why I should bother exercising	0	1	2	3	4
10	I enjoy my exercise sessions	0	1	2	3	4
11	I exercise because others will not be pleased with me if I don't	0	1	2	3	4
12	I don't see the point in exercising	0	1	2	3	4
13	I feel like a failure when I haven't exercised in a while	0	1	2	3	4
14	I think it is important to make the effort to exercise regularly	0	1	2	3	4
15	I find exercise a pleasurable activity	0	1	2	3	4
16	I feel under pressure from my friends or family to exercise	0	1	2	3	4
17	I get restless if I don't exercise regularly	0	1	2	3	4
18	I get pleasure and satisfaction from participating in exercise	0	1	2	3	4
19	I think exercising is a waste of time	0	1	2	3	4

David Markland PhD, C.Psychol
School of Sport, Health & Exercise Sciences
University of Wales, Bangor
E-mail: d.a.markland@bangor.ac.uk
April 2000
(http://pages.bangor.ac.uk/~pes004/exericse_motivation/breq/brqscore.htm)

Validation Study of BREQ-2:

Moreno, J.A., Cerveillo, E.M., and Martinez, A., 2007. Measuring self-determination motivation in a physical fitness setting: Validation of the Behavioral Regulation in Exercise Questionnaire-2 (BREQ-2) in a Spanish sample. *The Journal of Sport Medicine and Physical Fitness*, 47(3), pp.366–378.

BREQ-2 Online View in This Study:



WHY DO YOU ENGAGE IN PHYSICAL ACTIVITY?

Using the scale below, please indicate to what extent each of the following items is true for you. Please note that there are no right or wrong answers and no trick questions.

	Not very true for me	Not true for me	Sometimes true for for me	True for me	Very true for me
I am physically active because other people say I should	○	○	○	○	○
I feel guilty when I am not physically active	○	○	○	○	○
I value the benefits of physical activity	○	○	○	○	○
I am physically active because it's fun	○	○	○	○	○
I don't see why I should have to be physically active	○	○	○	○	○
I take part in physical activity because my friends/family/partner say I should	○	○	○	○	○
I feel ashamed when I miss a physical activity session	○	○	○	○	○
It's important to me to be physically active regularly	○	○	○	○	○
I can't see why I should bother to be physically active	○	○	○	○	○
I enjoy my physical activity sessions	○	○	○	○	○
I am physically active because others will not be pleased with me if I don't	○	○	○	○	○
I don't see the point in physical activity	○	○	○	○	○
I feel like a failure when I haven't been physically active in a while	○	○	○	○	○
I think it is important to make the effort to be physically active regularly	○	○	○	○	○
I find physical activity a pleasurable activity	○	○	○	○	○
I feel under pressure from my friends or family members to be physically active	○	○	○	○	○
I get restless if I am not regularly physically active	○	○	○	○	○
I get pleasure and satisfaction from participating in physical activity	○	○	○	○	○
I think physical activity is a waste of time	○	○	○	○	○

INTRINSIC MOTIVATION INVENTORY (IMI)

Actual IMI Questionnaire

For each of the following statements, please indicate how true it is for you, using the following scale:

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

Interest/Enjoyment							
I enjoyed doing this activity very much	1	2	3	4	5	6	7
This activity was fun to do	1	2	3	4	5	6	7
I thought this was a boring activity (R)	1	2	3	4	5	6	7
This activity did not hold my attention at all (R)	1	2	3	4	5	6	7
I would describe this activity as very interesting	1	2	3	4	5	6	7
I thought this activity was quite enjoyable	1	2	3	4	5	6	7
While I was doing this activity, I was thinking about how much I enjoyed it	1	2	3	4	5	6	7
Perceived Competence							
I think I am pretty good at this activity	1	2	3	4	5	6	7
I think I did pretty well at this activity, compared to other students	1	2	3	4	5	6	7
After working at this activity for awhile, I felt pretty competent	1	2	3	4	5	6	7
I am satisfied with my performance at this task	1	2	3	4	5	6	7
I was pretty skilled at this activity	1	2	3	4	5	6	7
This was an activity that I couldn't do very well (R)	1	2	3	4	5	6	7
Effort/Importance							
I put a lot of effort into this	1	2	3	4	5	6	7
I did not try very hard to do well at this activity (R)	1	2	3	4	5	6	7
I tried very hard on this activity	1	2	3	4	5	6	7
It was important to me to do well at this task	1	2	3	4	5	6	7
I did not put much energy into this (R)	1	2	3	4	5	6	7
Pressure/Tension							

I did not feel nervous at all while doing this	1	2	3	4	5	6	7
I felt very tense while doing this activity	1	2	3	4	5	6	7
I was very relaxed in doing these (R)	1	2	3	4	5	6	7
I was anxious while working on this task	1	2	3	4	5	6	7
I felt pressured while doing these	1	2	3	4	5	6	7

Perceived Choice

I believe I had some choice about doing this activity	1	2	3	4	5	6	7
I felt like it was not my own choice to do this task	1	2	3	4	5	6	7
I did not really have a choice about doing this task	1	2	3	4	5	6	7
I felt like I had to do this (R)	1	2	3	4	5	6	7
I did this activity because I had no choice (R)	1	2	3	4	5	6	7
I did this activity because I wanted to	1	2	3	4	5	6	7
I did this activity because I had to (R)	1	2	3	4	5	6	7

Value/Usefulness

I believe this activity could be of some value to me	1	2	3	4	5	6	7
I think that doing this activity is useful for _____	1	2	3	4	5	6	7
I think this is important to do because it can _____	1	2	3	4	5	6	7
I would be willing to do this again because it has some value to me	1	2	3	4	5	6	7
I think doing this activity could help me to _____	1	2	3	4	5	6	7
I believe doing this activity could be beneficial to me	1	2	3	4	5	6	7
I think this is an important activity	1	2	3	4	5	6	7

Relatedness

I felt really distant to this person (R)	1	2	3	4	5	6	7
I really doubt that this person and I would ever be friends (R)	1	2	3	4	5	6	7
I felt like I could really trust this person	1	2	3	4	5	6	7
I would like a chance to interact with this person more often	1	2	3	4	5	6	7
I would really prefer not to interact with this person in the future (R)	1	2	3	4	5	6	7
I don't feel like I could really trust this person (R)	1	2	3	4	5	6	7

It is likely that this person and I could become friends if we interacted a lot	1	2	3	4	5	6	7
I feel close to this person	1	2	3	4	5	6	7

Validation Study of IMI:

McAuley, E., Duncan, T. and Tammen, V.V., 1987. Psychometric properties of the intrinsic motivation inventory in a competitive sport setting: A confirmatory factor analysis. *Research Quarterly for Exercise and Sports*, 60, pp. 48–58.

IMI Online View In This Study:

For each of the following statements, please indicate how true it is for you, using the following scale:

	Not at all true	Very Untrue	Somewhat Untrue	Neither Untrue nor true	Somewhat true	Very true	Extremely true
I enjoy doing physical activity very much	○	○	○	○	○	○	○
Physical activity is fun to do	○	○	○	○	○	○	○
I think physical activity is boring	○	○	○	○	○	○	○
Physical activity does not hold my attention at all	○	○	○	○	○	○	○
I would describe physical activity as very interesting	○	○	○	○	○	○	○
I think physical activity is quite enjoyable	○	○	○	○	○	○	○
While I do physical activity, I think about how much I enjoy it	○	○	○	○	○	○	○
I think I am pretty good at physical activity	○	○	○	○	○	○	○
I think I do pretty well at physical activity compared to others	○	○	○	○	○	○	○
After working at physical activity for a while, i feel pretty competent	○	○	○	○	○	○	○
I am satisfied with my performance doing physical activity	○	○	○	○	○	○	○
I am pretty skilled at physical activity	○	○	○	○	○	○	○
Physical activity is an activity that I can't do very well	○	○	○	○	○	○	○
I put a lot of effort into physical activity	○	○	○	○	○	○	○
I do not try very hard to do well with physical activity	○	○	○	○	○	○	○
I try very hard with physical activity	○	○	○	○	○	○	○
It is important to me to do well with physical activity	○	○	○	○	○	○	○
I do not put much energy into being physically active	○	○	○	○	○	○	○
I do not feel nervous at all while being physically active	○	○	○	○	○	○	○
I feel very tense while doing physical activity	○	○	○	○	○	○	○
I am very relaxed while doing physical activity	○	○	○	○	○	○	○
I am anxious while being physically active	○	○	○	○	○	○	○
I feel pressured while being physically active	○	○	○	○	○	○	○
I believe I have some choice about doing physical activity	○	○	○	○	○	○	○

IMI Online View in This Study continued:

I feel like it is not my own choice to participate in physical activity	○	○	○	○	○	○	○
I do not really have a choice about participating in physical activity	○	○	○	○	○	○	○
I feel like I have to be physically active	○	○	○	○	○	○	○
I do physical activity because I have no choice	○	○	○	○	○	○	○
I do physical activity because I want to	○	○	○	○	○	○	○
I do physical activity because I have to	○	○	○	○	○	○	○
I believe physical activity can be of some value to me	○	○	○	○	○	○	○
I think that doing physical activity is useful for improving quality of life	○	○	○	○	○	○	○
I think physical activity is important to do because it can help in preventing disease	○	○	○	○	○	○	○
I am willing to be physically active again because it has some value to me	○	○	○	○	○	○	○
I think being physically active can help me to live a healthier life	○	○	○	○	○	○	○
I believe physical activity can be beneficial to me	○	○	○	○	○	○	○
I think physical activity is important	○	○	○	○	○	○	○

INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL
LOMA LINDA UNIVERSITY

INSTITUTIONAL REVIEW BOARD
RESEARCH PROTECTION PROGRAMS
24887 Taylor Street • Suite 202 • Loma Linda, CA 92350
(909) 558-4531 (voice) • (909) 558-0131 (fax)

Initial Approval Notice - Expedited ***IRB# 5140203***

To: **Medina Jr., Ernest**
Department: **Center for Nutrition Lifestyle & Disease Prevention**
Protocol: **The impact of gameful design on sedentary adults' motivation for physical activity and physical activity levels**

This study was reviewed and approved administratively on behalf of the IRB. This decision includes the following determinations:

Risk to research subjects: **Minimal**
Approval period begins: **28-Aug-2014** and ends **27-Aug-2015**
Stipulations of approval:
See attached list of items (if applicable).
See Appendix A for Conditions of Approval.

Adverse events and unanticipated problems must be reported in accord with the attached Adverse Event Reporting Matrix **A**.

All investigators are responsible for assuring that studies are conducted according to the approved protocol. Principal investigators are responsible for the actions of sub-investigators and staff with regard to this approval.

Please note the PI's name and the assigned IRB number, as indicated above, on any future communications with the IRB. Direct all communications to the IRB c/o Research Protection Programs. Thank you for your cooperation in LLU's shared responsibility for the ethical use of human subject in research.

Signature of IRB Chair/Designee: R L Rigsby
Date: 8/29/14

INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL EXTENSION
LOMA LINDA UNIVERSITY

LOMA LINDA UNIVERSITY

INSTITUTIONAL REVIEW BOARD
RESEARCH PROTECTION PROGRAMS
24887 Taylor Street • Suite 202 • Loma Linda, CA 92350
(909) 558-4531 (voice) • (909) 558-0131 (fax)

Extension Requested - Approval Notice Expedited ***IRB# 5140203***

To: **Medina Jr., Ernest**
Department: **Ctr for Nutrition Lifestyle and Disease Prevention**
Protocol: **The impact of gameful design on sedentary adults' motivation for physical activity and physical activity levels**

Your request to extend the protocol indicated above has been reviewed administratively. This review resulted in the following determinations:

Extension Request: **Approved**
Risk to research subjects: **Minimal**
Approval period begins: **27-Aug-2015** and ends **26-Aug-2016**
Stipulations of approval:

Consent Form

If this study was approved on the condition that a consent form is required AND subjects are still being enrolled, only the consent form bearing the IRB authorization stamp can be used. This will become your OFFICIAL consent form for the dates specified and should be used as the new master for making copies to give prospective subjects.

☐ Master consent form with up-dated authorized stamp enclosed.

☒ Updated consent form not required. Approval limited to data analysis or follow-up of currently enrolled subjects only.

☐ Not applicable; IRB approved a waiver of informed consent, as noted above.

IRB Communications

Please continue to notify the IRB in writing of any modifications or adverse events relating to the approved research protocol. Your assistance in providing the PI's name and the protocol's IRB # on all communications with the IRB about this project will expedite necessary communications.
Thank you for your cooperation in LLU's shared responsibility for the ethical use of human subjects in research.

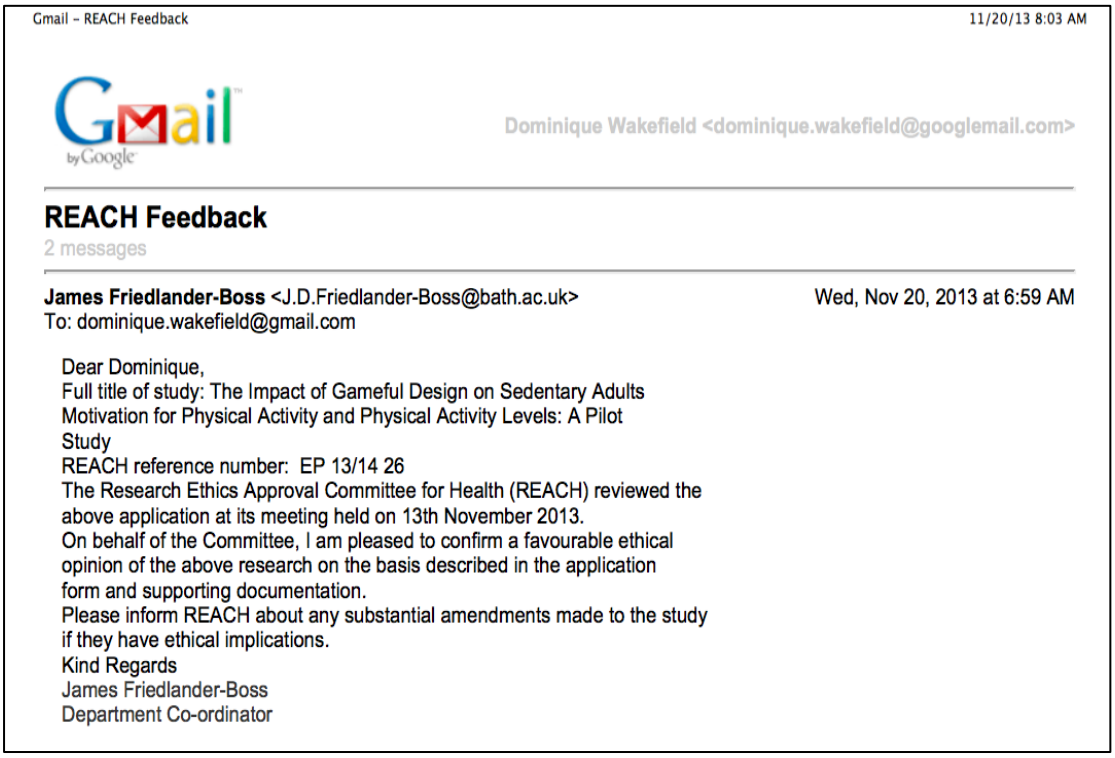
Signature of IRB Chair/Designee: _____ Date: 8/27/14

IRB Chair:
Travis Losey, MD
Department of Neurology
(909) 558-4531, tlosey@llu.edu, Pager #4290 for emergencies

IRB Administrator:
Linda G. Halstead, MA, Director
Research Protection Programs
Ext 43570, Fax 80131, lhalstead@llu.edu

IRB Analyst:
Anuradha Diekmann, MPH, CCRP, CIP
Research Protection Programs
Ext 86215, Fax 80131, adiekmann@llu.edu

UNIVERSITY OF BATH – ETHICS APPROVAL (REACH)



Gmail - REACH Feedback 11/20/13 8:03 AM

Gmail by Google

Dominique Wakefield <dominique.wakefield@googlemail.com>

REACH Feedback

2 messages

James Friedlander-Boss <J.D.Friedlander-Boss@bath.ac.uk> Wed, Nov 20, 2013 at 6:59 AM
To: dominique.wakefield@gmail.com

Dear Dominique,
Full title of study: The Impact of Gameful Design on Sedentary Adults Motivation for Physical Activity and Physical Activity Levels: A Pilot Study
REACH reference number: EP 13/14 26
The Research Ethics Approval Committee for Health (REACH) reviewed the above application at its meeting held on 13th November 2013.
On behalf of the Committee, I am pleased to confirm a favourable ethical opinion of the above research on the basis described in the application form and supporting documentation.
Please inform REACH about any substantial amendments made to the study if they have ethical implications.
Kind Regards
James Friedlander-Boss
Department Co-ordinator

SOUTHEASTERN CALIFORNIA CONFERENCE OF SEVENTH-DAY ADVENTISTS EXECUTIVE COMMITTEE APPROVAL FOR RECRUITMENT

Gmail by Google

Dominique Wakefield <dominique.wakefield@googlemail.com>

Research Approval

2 messages

Edna Thomas <Edna.Thomas@seccsda.org> Thu, Dec 5, 2013 at 5:10 PM
To: "dominique.wakefield@gmail.com" <dominique.wakefield@gmail.com>

Hi Dominique,

Here is the Executive Committee vote, taken today, to approve your research request:

VOTED to approve the research request from Dominique Wakefield. Dominique has all

necessary approvals available to the conference, which grants permission to request that SDA churches place a notice in their bulletins requesting for volunteer participation, subject to this Executive Committee approval.

Good luck!

Cheers and blessings,

Edna Thomas

Administrative Assistant

Office of the Executive Secretary

Southeastern California Conference

P.O. Box 79990

Riverside, CA 92513-1990

(951)509-2290

Dominique Wakefield <dominique.wakefield@googlemail.com> Thu, Dec 5, 2013 at 7:39 PM
To: Edna Thomas <Edna.Thomas@seccsda.org>

Dear Edna,

MEMORANDUM OF UNDERSTANDING
Dominique Wakefield & Center for Nutrition, Health Lifestyles, and Disease Prevention

Dominique Wakefield, M.A., CPT, CWP
Assistant Professor, Health & Exercise Science
La Sierra University
11510 Magnolia Ave. #1112
Riverside, CA 92505
Phone: 269-605-3595
E-Mail: wake@lasierra.edu

To:
Ernie Medina, Jr., DrPH, CHFS
Executive Director, Center for Nutrition, Healthy Lifestyles, and Disease Prevention
Loma Linda University - School of Public Health

MEMORANDUM OF UNDERSTANDING (MOU)
BETWEEN
DOMINIQUE WAKEFIELD &
CENTER FOR NUTRITION, HEALTHY LIFESTYLES, AND DISEASE PREVENTION

SUBJECT: PhD Research Project

1. **Purpose:** This MOU outlines the terms and conditions of the partnership between Dominique Wakefield and the Center for Nutrition, Healthy Lifestyles, and Disease Prevention in regards to the execution of ***Study Two*** *("Implementation and Evaluation of a Web-based, Gamefully Designed Physical Activity Intervention")* of the ***PhD Research Project***: *"The Impact of Gameful Design on Sedentary Adults' Motivation for Physical Activity and Physical Activity Levels".*

2. **Background:** Dominique Wakefield, M.A., CPT, CWP, is an Assistant Professor for Health and Exercise Science at La Sierra University and is currently working on her PhD in Health from the University of Bath, UK. Her PhD research will include three related, yet separate studies, of which ***Study Two*** will entail a randomized controlled physical activity intervention. Ms. Wakefield seeks a partnership with the Center for Nutrition, Healthy Lifestyles, and Disease Prevention to conduct her trial at Loma Linda University. Dr. Ernie Medina, Director of the Center, serves on Ms. Wakefield's supervisory committee for the PhD.

3. **Support & Resource Needs:**

   - Collaboration with the Center for Nutrition, Healthy Lifestyles, and Disease Prevention with Dr. Medina being the main contact person for Ms. Wakefield.
   - Utilization of space within the Preventive Care Clinic, working with Dr. Dos Santos on specific logistics.
   - Utilization of body composition equipment (BEI and scale) in the Preventive Care Clinic, working with Dr. Dos Santos on specific logistics.
   - Utilization of unpaid Loma Linda University graduate students to assist with data collection *(as part of their studies and/or for acquisition of experience, knowledge and skills in research)*
   - Solicitation of potential volunteer subjects from student body, faculty and staff of Loma Linda University for participation in the intervention (with approval of appropriate IRB and compliance of IRB rules and regulations at Loma Linda University)

4. **Contracting Period:** May 1, 2014 - December 31, 2015

5. **Effective Date:** This agreement will become effective on May 1, 2014.

Signature - Assoc. Dean for Research, SPH	5/2/14 Date	Signature - Dominique Wakefield	Date
Signature - Center for NHLDP Director	5-5-14 Date		

RESEARCH TEAM ON SITE

Primary Investigator = PI
Research Assistant = RA

	WHAT	OCCUPATION	TASKS	DATES
1	PI	PhD Health/Assistant Professor, Health & Exercise Science	Lead on everything	Whole project
2	PI	Director/Assistant Professor, Public Health	Field-based supervisor IRB communicator	Whole project
3	RA #1	Assistant Professor, Health & Exercise Science	Data collection Data downloading Administrative	14/08 – 15/12
4	RA #2	Manager, Wholeness Institute	Data collection Administrative	14/08 – 15/12
5	RA #3	Graduate Student	Data collection	14/08 – 14/12
6	RA #4	Undergraduate Student, pre-med	Data collection	14/08 – 15/08
7	RA #5	Undergraduate Student/Nurse	Data collection Administrative	15/01 – 15/10
8	RA #6	Undergraduate Student, pre-med	Data collection	15/02 – 15/08
9	RA #7	Undergraduate Student, pre-PT	Data collection	15/07 – 15/09
10	RA #8	Assistant Professor, Health & Exercise Science	Data collection Administrative	15/08 – 15/12
11	Statistician	Associate Professor, Public Health/Biostatistics	Sample Size Data analysis	Whole project

All research team members had to complete the Human Subjects Education (HSE) course and get approved by IRB at LLU.

HUMAN SUBJECTS EDUCATION (HSE) AT LLU

(Evidence of completion for Dominique Wakefield)

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI)

BASIC/REFRESHER COURSE IN HUMAN SUBJECTS RESEARCH CURRICULUM COMPLETION REPORT

Printed on 07/21/2014

LEARNER	Dominique Wakefield (ID: 4260703)
DEPARTMENT	Health & Exercise Science
EMAIL	wake@lasierra.edu
INSTITUTION	Loma Linda University
EXPIRATION DATE	07/20/2016

SOCIAL & BEHAVIORAL RESEARCH INVESTIGATORS

COURSE/STAGE:	Basic Course/1
PASSED ON:	07/21/2014
REFERENCE ID:	13530097

REQUIRED MODULES	DATE COMPLETED
Introduction	07/21/14
History and Ethical Principles - SBE	07/21/14
Defining Research with Human Subjects - SBE	07/21/14
The Regulations - SBE	07/21/14
Assessing Risk - SBE	07/21/14
Informed Consent - SBE	07/21/14
Privacy and Confidentiality - SBE	07/21/14
Research with Prisoners - SBE	07/21/14
Research with Children - SBE	07/21/14
Research in Public Elementary and Secondary Schools - SBE	07/21/14
International Research - SBE	07/21/14
Internet Research - SBE	07/21/14
Research and HIPAA Privacy Protections	07/21/14
Vulnerable Subjects - Research Involving Workers/Employees	07/21/14
Conflicts of Interest in Research Involving Human Subjects	07/21/14
Loma Linda University	07/21/14

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI Program participating institution or be a paid Independent Learner. Falsified information and unauthorized use of the CITI Program course site is unethical, and may be considered research misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Program Course Coordinator

INFORMED CONSENT FORM

LOMA LINDA UNIVERSITY
School of Public Health

INFORMED CONSENT

TITLE: **THE IMPACT OF GAMEFUL DESIGN ON SEDENTARY ADULTS' MOTIVATION FOR PHYSICAL ACTIVITY AND PHYSICAL ACTIVITY LEVELS**

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1. WHY IS THIS STUDY BEING DONE?

The purpose of this study is to explore new and effective ways for people to increase their motivation for physical activity and their physical activity levels for better health and fitness.

Physical inactivity is a rising public health concern and is the fourth leading risk factor for mortality worldwide. Rigorous research is necessary to identify more effective methods to increase physical activity levels and decrease sedentary behaviour. The concept of gamification (the use of game elements in non-game contexts) has shown potential for increasing user engagement, user activity, user productivity and social interactions; however, many gamefully designed activity tools have not been properly evaluated.

You are invited to participate in this research study to help us evaluate the effectiveness and impact of web-based gameful design for physical activity.

Approximately 124 subjects will participate in this study at LLU. If these numbers cannot be achieved at LLU, additional participants may be recruited at La Sierra University (Riverside, CA) and through the Southeastern California Conference of Seventh-day Adventists (Inland Empire).

2. HOW LONG WILL THE STUDY GO ON?

Your participation in this study will last six months with one additional appointment within one to three months following the initial six months. During the duration of the study, you will be asked to come to the study center at LLU ten different times at specific appointment dates that will be made with you individually.

3. HOW WILL I BE INVOLVED?

You can participate in this study if :

- you are an adult between the ages of 25 – 44
- you are sedentary (physically inactive)
- you are cleared to participate in physical activity (per the screening survey & medical clearance from the doctor if necessary)
- you are physically able to walk with two legs across the room
- you are able to read and write in English
- you are able to access Internet daily via personal computer, smartphone or tablet
- your BMI is under 40
- you are able to commit for the time frame of six months plus one additional appointment during one to three months after the initial six months
- you are able to come to the study center on ten occasions during the duration of the study

You cannot participate in this study if:

- you have a medical condition that would prevent participation in the simplest form of physical activity (walking)
- you have answered more than one question with 'yes' on specific questions of the screening survey and cannot produce a medical clearance form

Description of Participant Commitment

⇒ (NOTE: See flowchart on page five for a clear sequence of events)

Depending on which group you are assigned to, you may be asked to engage in physical activity of your own choosing. You will choose how much, when, what and for how long. You will be asked to wear an accelerometer (a device that tracks physical activity and looks like a wristwatch) for one week at a time at the following time points within this study: at the beginning, after six weeks, after three months and after six months. You will be asked to briefly stop by the research headquarters, so that researchers can extract information from the devices you are wearing and check the accelerometers in and out to you for a one-week period at a time. Different technological tools may be provided to some individuals involved in the study (which may include accessing the Internet on a daily basis). In addition to wearing an accelerometer, you will be asked to complete a set of questionnaires at the four time points throughout the six-months period, which each will not take longer than five to ten minutes.

You may be asked to take part in a short interview (either in person or over the phone) immediately following the six-months time point, which will be recorded with your permission. Prior to wearing the accelerometer each time, you would be required to come to the research headquarters, where we would collect some basic biometric data (your height, weight, age, gender, BMI and body fat percentage). Again, this same biometric data will be collected at the four different time points throughout the six-months period. This will not take more than five minutes each time.

If you agree to participate, you will be responsible for completing the tasks outlined in this section and for informing co-investigator Dominique Wakefield, if you choose to withdraw from the study at any point.

4. WHAT ARE THE REASONABLY FORESEEABLE RISKS OR DISCOMFORTS I MIGHT HAVE?

Engaging in any physical activity may cause some physical soreness and there is a potential for injury. You will receive a physical activity safety handout with tips to minimize getting injured, hurt or sore for participating in any physical activity.

5. WILL THERE BE ANY BENEFIT TO ME OR OTHERS?

Your involvement in this research study will provide you with the opportunity to make positive changes to your physical activity behaviors. Depending on which group you will be randomly assigned to you may receive access to a variety of helpful tools to assist with the increase in physical activity behavior. Being physically active has many physiological, mental and emotional benefits. By participating you also have the option to receiving a detailed report of your physical activity behaviors.

In addition, the information learned from this study will also benefit others by helping us develop more effective gamefully designed physical activity programs.

We will be happy to share the results of this study with you if you provide your email at the time of the prescreening.

6. WHAT ARE MY RIGHTS AS A SUBJECT?

Participation in this study is voluntary. Your decision whether or not to participate or withdraw at any time from the study will not affect your ongoing relationship with any caregivers and will not involve any penalty or loss of benefits to which you are otherwise entitled.

7. WHAT HAPPENS IF I WANT TO STOP TAKING PART IN THIS STUDY?

- You are free to withdraw from this study at any time. If you decide to withdraw from this study you should notify the research team immediately. The research team may also end your participation in this study if you do not follow instructions, miss scheduled visits, or if your safety and welfare are at risk.
- If you experience any of the discomforts listed above, or if you are injured during the research, you may need to be withdrawn from the study, even if you would like to continue. The research team will make this decision and let you know if it is not possible for you to continue. The decision may be made to protect your safety and welfare.
- If you withdraw or are removed from the study, the researcher may ask you to return the accelerometer device.
- Likewise, your participation in the study may be stopped by the study staff/investigator for any reason without your agreement.

8. HOW WILL INFORMATION ABOUT ME BE KEPT CONFIDENTIAL?

Efforts will be made to keep your personal information confidential. You will be identified by a code rather than a name. The information and data will be stored in password-protected computer files and locked up cabinets, which can only be accessed by the research team. Your name will not be disclosed. Some of your comments may be used word for word when the research team is compiling the data analysis, but you will not be identified.

We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. You will not be identified by name in any publications describing the results of this study.

Interviews will be recorded (audio) with your permission and the digital audio files will be kept in password-protected computer files, which can only be accessed by the research team. Recordings will be kept in a locked and safe location for at least three years after the end of the study. At that point, the recordings will be safely destroyed.

9. WHAT COSTS/PAY ARE INVOLVED?

There is no cost to you for participating in this study. You will not be paid to participate in this research study.

10. WILL STUDY STAFF RECEIVE PAYMENT?

The entire study staff is conducting this research voluntarily. This research study is part of the fulfillment of a PhD research project of co-investigator, Dominique Wakefield. The primary investigator, Ernesto Medina, DrPH, is one of Mrs. Wakefield's PhD supervisors.

11. WHO DO I CALL IF I HAVE QUESTIONS?

Call 909-558-4647 or e-mail patientrelations@llu.edu for information and assistance with complaints or concerns about your rights in this study.

12. SUBJECT'S STATEMENT OF CONSENT

- I have read the contents of the consent form and have listened to the verbal explanation given by the research investigator.
- My questions concerning this study have been answered to my satisfaction.
- Signing this consent document does not waive my rights nor does it release the investigators, institution or sponsors from their responsibilities.
- I may call Dominique Wakefield at (951) 785-2293 if I have additional questions or concerns.
- I hereby give voluntary consent to participate in this study.

I understand I will be given a copy of this consent form after signing it.

Signature of Subject	Printed Name of Subject
Date	Place

13. INVESTIGATOR'S STATEMENT

I have reviewed the contents of this consent form with the person signing above. I have explained potential risks and benefits of the study.

Signature of Investigator	Printed Name of Investigator
Date	

Attachment 1: Study Flow Chart

	Before study begins	**Week 1** Visit 1	**Week 1** Visit 2	**Week 7** Visit 3	**Week 7** Visit 4	**Week 13** Visit 5	**Week 13** Visit 6	**Week 25** Visit 7	**Week 25** Visit 8	**Week 25 - 39**
Pre-screening	X									
Consent Form/HIPAA Appointment	X									
Biometric measurements		X		X		X		X		
Questionnaires		X		X		X		X		
Aceelerometer data		X		X		X		X		
Return of accelerometer			X		X		X		X	
Interview (one appointment only)										X

SCRIPTS FOR APPOINTMENTS

APPOINTMENT #1 SCRIPT

Wakefield PhD Research 09.03.2014

Appointment #1 (DAY 1)

CHECKLIST FOR RESEARCH ASSISTANT

- Arrive five minutes before your shift wearing your research T-shirt and a professional pair of pants or shorts (black or beige, not workout clothes).
- Note down your arrival time in the "Research Assistant Clock-In/Clock-out" folder *(that folder will also contain the research overview document and all the scripts for appointments)*
- Make sure that body fat analyzer is turned on when you arrive.
- Make sure that printer is turned on and proper paper (with the template) is inserted correctly.
- Check the online calendar for appointments.
- Check the manual participant file to see if everything is in order with participant file (yellow = control group; red = INT group)
- Stand outside the door of the Preventive Care Clinic office to welcome participant (if you know that an appointment is supposed to arrive).
- Once participant arrives, use script this script:

1. **Welcome to your first appointment! My name is _____ and on behalf of the research team, I would like to thank you for enrolling in this research study. Please have a seat.**

2. **Let me give you a brief overview of this appointment:**
   a. **First, I will double-check that all is in order with your Consent Form and HIPAA Form**
   b. **Second, I will set up the laptop here for you to take a quick online questionnaire**
   c. **Third, we will take your height, weight, BMI and body fat percentage (which I cannot share with you at this time due to this being a research study and the results may influence your behavior)**
   d. **Fourth, I will set up an accelerometer device for you to wear for the next seven full days and give you a quick introduction about the device.**
   e. **Lastly, we will schedule the next appointment for you to return the accelerometer device.**

⇒ **Do you have any questions before we begin?**

- Check participant manual file for signed Consent Form and HIPAA Form. Please ensure that the participant has signed it and that either Ernie or Dominique signed it.
- Check participant manual file for accurate ID number, which should be marked on the side tab. You can verify that number by asking the participant for their birthdate. The participant, however, **DOES NOT KNOW** whether they are in the Intervention Group or the Control Group, so **DO NOT** ask them that. We will have coded the folders with **"INT"** after their 6-digit birthday code, which will let you know, which group they are in (plus, red hanging files indicate = INT group)

APPOINTMENT #1 SCRIPT continued

Wakefield PhD Research 09.03.2014

- Set up online questionnaire for participant on laptop and make sure they insert their research ID code properly as they begin taking the survey. Explain to them how the online survey works and then let them take it. Assure them that you are available if they have a question, but then sit or stand in a corner of the space so they know you are NOT watching them take the survey.
- Begin biometric measurement sequence: have them take off their shoes and then first do height in inches
- Conduct body fat analysis on machine getting the print out, making sure we have weight, BMI and body fat percentage. Make sure participant DOES NOT see the results.
- Put the printout in their file folder immediately
- Ask them to put their shoes back on and have them sit down next to you.
- Explain to them that they will wear an accelerometer for the next seven days, show it to them and explain to them what it does and the "rules" for wearing it (using the accelerometer script).
- Configure the accelerometer for the participant.
- Write down the accelerometer number and the participant ID number on the Accelerometer Check-Out /Check-In form (see corresponding folder)
- Have them put on the accelerometer on the hand indicated during configuration.
- State again: **"PLEASE DO NOT TAKE OFF THIS ACCELEROMETER BEFORE YOU RETURN TO YOUR NEXT APPOINTMENT".**
- Give them the "tracking sheet" (copies in accelerometer folder) and explain that if for whatever reason they take off the accelerometer, they need to document the date, timeframe and reason why they took it off. Tell them that they need to bring it back to the next appointment
- Ask them if they have any questions.
- Make an appointment for Day 9 (look on the calendar for what that means). First put the appointment on the online calendar, then make an appointment card for the participant and emphasize that it is really important for them to keep the appointment (contact info is on the appointment card just in case).
- Thank them for coming and wish them a good day.

POST APPOINTMENT:

- Write the next appointment (include participant ID number and phone number) in the manual appointment book as a back-up and put a checkmark next to the completed appointment in the appointment book.
- Copy the height, weight, BMI and body fat percentage result onto the Biometric measurement template and put it in participant's file folder.
- Indicate on the printout from the machine, that this was appointment #1 measurements and indicate participant's ID number on the printout and also put it in participant's file folder.

APPOINTMENT #2 SCRIPT

Wakefield PhD Research 09.03.2014

Appointment #2 (DAY 9)

CHECKLIST FOR RESEARCH ASSISTANT

- Arrive five minutes before your shift wearing your research T-shirt and a professional pair of pants or shorts (black or beige, not workout clothes).
- Note down your arrival time in the "Research Assistant Clock-In/Clock-Out" folder.
- Check the online calendar for appointments.
- Check the manual file to see if everything is in order with participant file.
- Make sure you know exactly if appointment is an Intervention Group OR Control Group for this appointment. **THIS IS VITAL!!!**
- Stand outside the door of the Preventive Care Clinic office to welcome participant (if you know that an appointment is supposed to arrive).
- Once participant arrives, use the appropriate script and then proceed with the appropriate checklist on the next page:

Script

1. Welcome back to your second appointment! My name is _____ and I want to thank you for coming to your appointment today!

(Note: if you remember this person, tell them "nice to see you again", but never ask people for their names!!).

INTERVENTION GROUP SUBJECT	CONTROL GROUP SUBJECT
Let me give you a brief overview of this appointment: a. **First**, I will collect your accelerometer. b. **Second,** I will introduce you to an online tool for physical activity and set up a profile for you. c. **Third**, I will provide a short training for you for this online tool d. **Fourth,** I will give you a handout with some tips for safety for physical activity e. **Lastly,** we will schedule the next appointment for you to come back again in six weeks from today. ⇒ Do you have any questions before we begin?	Let me give you a brief overview of this appointment: o **First**, I will collect your accelerometer. o **Second,** I will give you a handout with some tips for safety for physical activity. o **Lastly,** we will schedule the next appointment for you to come back again in six weeks from today. ⇒ Do you have any questions before we begin?

APPOINTMENT #2 SCRIPT continued

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INTERVENTION GROUP SUBJECT	CONTROL GROUP SUBJECT
○ Have participant hand you the accelerometer ○ Ask if they took off the accelerometer at ANY time during the last seven days. If so, ask them for their "tracking sheet". If they don't have it, use a blank template and see if they can recall when and why they took it off so you can document it for them at the appointment. Then put it in their folder. ○ Use the "Accelerometer Check-In/Check-Out" sheet to CHECK IN this particular accelerometer # ○ Put accelerometer in the appropriate box in the drawer labeled "FULL" ○ Explain to subject that you will now get them set up with an online site, which will be fun, enjoyable and helpful for physical activity (use Fitocracy script) ○ Pull up Fitocracy page and let participant register, BUT you give them the username and password (username=research ID#; password=reversed ID#) ○ Write down research ID#, log-in and password for Fitocracy on the appropriate tracking sheet found in the "Accelerometer Check-In/Check-Out" folder. ○ Help participant set up their profile and give them a short introduction to Fitocracy (use Fitocracy script) ○ Explain to participant that engaging with this online site over the next six week is important and part of the study (use Fitocracy script) ○ Hand subject the PA Safety Information Sheet (copies in a folder) and simply ask them to read it before they engage in physical activity ○ Make the next appointment (#3 = Day 52) for 42 days later on the online calendar. ○ Fill out an appointment card and give it to participant and thank them for coming to this appointment and wish them an excellent six weeks until the next appointment!	○ Have participant hand you the accelerometer ○ Ask if they took off the accelerometer at ANY time during the last seven days. If so, ask them for their "tracking sheet". If they don't have it, use a blank template and see if they can recall when and why they took it off so you can document it for them at the appointment. Then put it in their folder. ○ Use the accelerometer check-in/check-out sheet to CHECK IN this particular accelerometer # ○ Put accelerometer in the appropriate box in the drawer labeled "FULL" ○ Hand subject the PA Safety Information Sheet (copies in a folder) and simply ask them to read it before they engage in any physical activity. ○ Make the next appointment (#3 = Day 52) for 42 days later on the online calendar. ○ Fill out an appointment card and give it to participant and thank them for coming to this appointment and wish them an excellent six weeks until the next appointment!

POST APPOINTMENT:

- Write the next appointment (include participant ID number and phone number) in the manual appointment book as a back-up and put a checkmark next to the completed appointment in the appointment book.
- Make sure that ID#, username and password for Intervention Group participants was copied onto Fitocracy sheet.
- Make sure that collected accelerometer was manually checked-in on the manual sheet and that that accelerometer was put in the box labeled "FULL".

APPOINTMENT #3 SCRIPT

Wakefield PhD Research 10.31.2014

Appointment #3 = FOLLOW-UP #1 (Day 52) (6-week follow-up)

1. Greet the subject and welcome them to appointment #3. DO NOT engage in a discussion about how they have been doing or anything like that. You should not verbally ask/engage in conversation about Fitocracy or any other element of physical activity.

2. Depending on whom you are meeting with (Intervention or control) follow the correct column below and give the subject a brief overview what will take place in today's session.

INTERVENTION Group	Control Group
1. **PENS Questionnaire (paper)** *(NOTE: these will be in folder in the back in the top drawer)* 2. **Online questionnaire (onsite)** *(NOTE: use the new tab on Google Chrome)* 3. **Lab-measured height, weight, BMI and body composition** *(NOTE: use the same sheet in their folders to record the data)* 4. **Research assistant will configure accelerometer for 7-day period** *(NOTE: remember to check-out accelerometer in book notating the actual # of device & subject ID)* 5. **Subject is provided next appointment reminder (in 7 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule and remind subject to NOT take off accelerometer at all! Give them a sheet to record any event where they would have to take it off.)* 6. **Tell subject: *"Between now and your next appointment, feel free to continue using Fitocracy with the log-in and password you have been using. Do not change your log-in or password while you are in the study."*** 7. **Tell subject: *"Feel free to invite people you know to join Fitocracy by sending them an 'invite' via the personal profile."*** 8. **Ask subject: *"We are still in need of recruiting more people for this study. Would you be willing to invite someone you know who qualifies?"*** (hand subject 5 black business cards with study info and thank them!) 9. **Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort!"***	1. **Online questionnaire (onsite)** *(NOTE: use the new tab on Google Chrome)* 2. **Lab-measured height, weight, BMI and body composition** *(NOTE: use the same sheet in their folders to record the data)* 3. **Research assistant will configure accelerometer for 7-day period** *(NOTE: remember to check-out accelerometer in book notating the actual # of device & subject ID)* 4. **Subject is provided next appointment reminder (in 7 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule and remind subject to NOT take off accelerometer at all! Give them a sheet to record any event where they would have to take it off.)* 5. **Ask subject: *"We are still in need of recruiting more people for this study. Would you be willing to invite someone you know who qualifies?"*** (hand subject 5 black business cards with study info and thank them!) 6. **Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort!"***

APPOINTMENT #4 SCRIPT

Wakefield PhD Research 10.31.2014

Appointment #4 = Accelerometer Return #2 (Day 60) (6-week follow-up)

1. Greet the subject and welcome them to appointment #4. DO NOT engage in a discussion about how they have been doing or anything like that. You should not verbally ask/engage in conversation about Fitocracy or any other element of physical activity.

2. Depending on whom you are meeting with (Intervention or control) follow the correct column below and give the subject a brief overview what will take place in today's session.

INTERVENTION Group	Control Group
1. Take the accelerometer and determine the condition and record on check-in sheet in the folder. Put accelerometer in the FULL box. **2. Ask subject if they took off the accelerometer at any point. If 'YES', ask them for the sheet where they noted down that they took it off. If they have it, put it in their folder. If they don't have it, use a blank one and try to fill it out with participant as best as they remember.** **3. Subject is provided next appointment reminder (in 34 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule)* ***4.*** **Tell subject: *"Between now and your next appointment, feel free to continue using Fitocracy with the log-in and password you have been using. Do not change your log-in or password while you are in the study."*** *5.* **Tell subject: *"Feel free to invite people you know to join Fitocracy by sending them an 'invite' via the personal profile."*** *6.* **Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort! Thank you also for seeing if you can invite someone else you know to participate in the study."***	**1. Take the accelerometer and determine the condition and record on check-in sheet in the folder. Put accelerometer in the FULL box.** **2. Ask subject if they took off the accelerometer at any point. If 'YES', ask them for the sheet where they noted down that they took it off. If they have it, put it in their folder. If they don't have it, use a blank one and try to fill it out with participant as best as they remember.** **3. Subject is provided next appointment reminder (in 34 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule)* *4.* **Tell subject: *"Between now and your next appointment remember to stay safe following the safety information sheet received earlier on in the study if you choose to be physically active.*** *5.* **Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort! Thank you also for seeing if you can invite someone else you know to participate in the study."***

APPOINTMENT #5 SCRIPT

Wakefield PhD Research 10.31.2014

Appointment #5 = FOLLOW-UP #2 (Day 94) (3-months follow-up)

1. Greet the subject and welcome them to appointment #5. DO NOT engage in a discussion about how they have been doing or anything like that. You should not verbally ask/engage in conversation about Fitocracy or any other element of physical activity.

2. Depending on whom you are meeting with (Intervention or control) follow the correct column below and give the subject a brief overview what will take place in today's session.

INTERVENTION Group	Control Group
1. Online questionnaire (onsite) *(NOTE: use the new tab on Google Chrome)* **2. Lab-measured height, weight, BMI and body composition** *(NOTE: use the same sheet in their folders to record the data)* **3. Research assistant will configure accelerometer for 7-day period** *(NOTE: remember to check-out accelerometer in book notating the actual # of device & subject ID)* **4. Subject is provided next appointment reminder (in 7 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule and remind subject to NOT take off accelerometer at all! Give them a sheet to record any event where they would have to take it off.)* ***5.*** **Tell subject: *"Between now and your next appointment, feel free to continue using Fitocracy with the log-in and password you have been using. Do not change your log-in or password while you are in the study."*** **6. Tell subject: *"Feel free to invite people you know to join Fitocracy by sending them an 'invite' via the personal profile."*** **7. Ask subject: *"We are still in need of recruiting more people for this study. Would you be willing to invite someone you know who qualifies?"*** (hand subject 5 black business cards with study info and thank them!) **8. Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort!"***	**1. Online questionnaire (onsite)** *(NOTE: use the new tab on Google Chrome)* **2. Lab-measured height, weight, BMI and body composition** *(NOTE: use the same sheet in their folders to record the data)* **3. Research assistant will configure accelerometer for 7-day period** *(NOTE: remember to check-out accelerometer in book notating the actual # of device & subject ID)* **4. Subject is provided next appointment reminder (in 7 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule and remind subject to NOT take off accelerometer at all! Give them a sheet to record any event where they would have to take it off.)* **5. Ask subject: *"We are still in need of recruiting more people for this study. Would you be willing to invite someone you know who qualifies?"*** (hand subject 5 black business cards with study info and thank them!) **6. Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort!"***

APPOINTMENT #6 SCRIPT

Wakefield PhD Research 10.31.2014

Appointment #6 = Accelerometer Return #3 (Day 102) (3-months follow-up)

1. Greet the subject and welcome them to appointment #6. DO NOT engage in a discussion about how they have been doing or anything like that. You should not verbally ask/engage in conversation about Fitocracy or any other element of physical activity.

2. Depending on whom you are meeting with (Intervention or control) follow the correct column below and give the subject a brief overview what will take place in today's session.

INTERVENTION Group	**Control Group**
1. Take the accelerometer and determine the condition and record on check-in sheet in the folder. Put accelerometer in the FULL box. **2. Ask subject if they took off the accelerometer at any point. If 'YES', ask them for the sheet where they noted down that they took it off. If they have it, put it in their folder. If they don't have it, use a blank one and try to fill it out with participant as best as they remember.** **3. Subject is provided next appointment reminder (in 88 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule)* ***4. Tell subject: "Between now and your next appointment, feel free to continue using Fitocracy with the log-in and password you have been using. Do not change your log-in or password while you are in the study."*** ***5. Tell subject: "Feel free to invite people you know to join Fitocracy by sending them an 'invite' via the personal profile."*** ***6. Tell subject: "Thank you very much for participating in this study. We really value your commitment and effort! Thank you also for seeing if you can invite someone else you know to participate in the study."***	**1. Take the accelerometer and determine the condition and record on check-in sheet in the folder. Put accelerometer in the FULL box.** **2. Ask subject if they took off the accelerometer at any point. If 'YES', ask them for the sheet where they noted down that they took it off. If they have it, put it in their folder. If they don't have it, use a blank one and try to fill it out with participant as best as they remember.** **3. Subject is provided next appointment reminder (in 88 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule)* *4.* **Tell subject: *"Between now and your next appointment remember to stay safe following the safety information sheet received earlier on in the study if you choose to be physically active.*** *5.* **Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort! Thank you also for seeing if you can invite someone else you know to participate in the study."***

APPOINTMENT #7 SCRIPT

Wakefield PhD Research 10.31.2014

Appointment #7 = FOLLOW-UP #3 (Day 190) (6-months follow-up)

1. Greet the subject and welcome them to appointment #7. DO NOT engage in a discussion about how they have been doing or anything like that. You should not verbally ask/engage in conversation about Fitocracy or any other element of physical activity.

2. Depending on whom you are meeting with (Intervention or control) follow the correct column below and give the subject a brief overview what will take place in today's session.

INTERVENTION Group	Control Group
1. **Online questionnaire (onsite)** *(NOTE: use the new tab on Google Chrome)* 2. **Lab-measured height, weight, BMI and body composition** *(NOTE: use the same sheet in their folders to record the data)* 3. **Research assistant will configure accelerometer for 7-day period** *(NOTE: remember to check-out accelerometer in book notating the actual # of device & subject ID)* 4. **Subject is provided next appointment reminder (in 7 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule and remind subject to NOT take off accelerometer at all! Give them a sheet to record any event where they would have to take it off.)* 5. **Tell subject: *"Between now and your next appointment, feel free to continue using Fitocracy with the log-in and password you have been using. Do not change your log-in or password while you are in the study."*** 6. **Tell subject: *"Feel free to invite people you know to join Fitocracy by sending them an 'invite' via the personal profile."*** 7. **Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort!"***	1. **Online questionnaire (onsite)** *(NOTE: use the new tab on Google Chrome)* 2. **Lab-measured height, weight, BMI and body composition** *(NOTE: use the same sheet in their folders to record the data)* 3. **Research assistant will configure accelerometer for 7-day period** *(NOTE: remember to check-out accelerometer in book notating the actual # of device & subject ID)* 4. **Subject is provided next appointment reminder (in 7 full days)** *(NOTE: provide appointment card, notate appt. on online & manual schedule and remind subject to NOT take off accelerometer at all! Give them a sheet to record any event where they would have to take it off.)* 5. **Tell subject: *"Thank you very much for participating in this study. We really value your commitment and effort!"***

APPOINTMENT #8 SCRIPT

Wakefield PhD Research 10.31.2014

Appointment #8 = Accelerometer Return #4 (Day 198) (6-months follow-up)

1. Greet the subject and welcome them to appointment #8. DO NOT engage in a discussion about how they have been doing or anything like that. You should not verbally ask/engage in conversation about Fitocracy or any other element of physical activity.

2. Depending on whom you are meeting with (Intervention or control) follow the correct column below and give the subject a brief overview what will take place in today's session.

INTERVENTION Group	Control Group
1. Take the accelerometer and determine the condition and record on check-in sheet in the folder. Put accelerometer in the FULL box. **2. Ask subject if they took off the accelerometer at any point. If 'YES', ask them for the sheet where they noted down that they took it off. If they have it, put it in their folder. If they don't have it, use a blank one and try to fill it out with participant as best as they remember.** **3. Ask subject: "Would you be willing to participate in a follow-up in-person interview with one of the primary investigators of this research study?" (If YES, tell them that we MAY contact them to set up an appointment. If NO, tell them thank you and that that is completely fine).** *(NOTE: Notate in the folder and on the sheet provided their research ID #, their phone number, email and whether they are willing to participate in an interview or not)* **4. Ask subject: "Would you like to obtain a copy of your personal biometric and accelerometer data from the last 6 months?"** *(NOTE: Notate their answer on the corresponding sheet in folder with contact information)* ***5. Tell subject: "Thank you very much for participating in this study. We really value your commitment and effort!*** *(NOTE: Hand them our little thank you cards/certificate of completion of being in a research study)*	**1. Take the accelerometer and determine the condition and record on check-in sheet in the folder. Put accelerometer in the FULL box.** **2. Ask subject if they took off the accelerometer at any point. If 'YES', ask them for the sheet where they noted down that they took it off. If they have it, put it in their folder. If they don't have it, use a blank one and try to fill it out with participant as best as they remember.** **3. Ask subject: "Would you be willing to participate in a follow-up in-person interview with one of the primary investigators of this research study?" (If YES, tell them that we MAY contact them to set up an appointment. If NO, tell them thank you and that that is completely fine).** *(NOTE: Notate in the folder and on the sheet provided their research ID #, their phone number, email and whether they are willing to participate in an interview or not)* **4. Ask subject: "Would you like to obtain a copy of your personal biometric and accelerometer data from the last 6 months?"** *(NOTE: Notate their answer on the corresponding sheet in folder with contact information)* ***5. Tell subject: "Thank you very much for participating in this study. We really value your commitment and effort!*** *(NOTE: Hand them our little thank you cards/certificate of completion of being in a research study)*

The Player Experience of Need Satisfaction (PENS)

NOTE: This questionnaire has been modified to fit the context of this research study. Instead of "game", we substituted the name of the gamified intervention "Fitocracy". Instead of "play", the word "use" was substituted as appropriate.

Administration Guidelines:

- ⇒ Respondents typically rate their level of agreement to each item using a 7-point Likert scale (1= Do Not Agree, 7=Strongly Agree);
- ⇒ All items are weighted equally in scoring;
- ⇒ Items are randomized in their order when presented to participants
- ⇒ Reverse-scored items are indicated by "(-)"
- ⇒ Questions are framed by the following stem:

"Reflect on your play experiences and rate your agreement with the following statements:"

PENS: Competence

Reflect on your play experiences and rate your agreement with the following statements:

1. I feel competent at Fitocracy.
2. I feel very capable and effective when using Fitocracy.
3. My ability to use Fitocracy is well matched with the game's challenges.

PENS: Autonomy

Reflect on your play experiences and rate your agreement with the following statements:

1. Fitocracy provides me with interesting options and choices.
2. Fitocracy lets you do interesting things.
3. I experienced a lot of freedom in Fitocracy.

PENS: Relatedness

Reflect on your play experiences and rate your agreement with the following statements:

1. I find the relationships I form in Fitocracy fulfilling.
2. I find the relationships I form in Fitocracy important.
3. I don't feel close to other players. (-)

Presence/Immersion

1. When using Fitocracy, I feel transported to another time and place.
2. Exploring the Fitocracy world feels like taking an actual trip to a new place.
3. When moving through the Fitocracy world I feel as if I am actually there.
4. I am not impacted emotionally by events in Fitocracy (-).
5. Fitocracy was emotionally engaging.
6. I experience feelings as deeply in Fitocracy as I have in real life.
7. When playing Fitocracy I feel as if I was part of the story.
8. When I accomplished something in Fitocracy I experienced genuine pride.
9. I had reactions to events and characters in Fitocracy as if they were real.

PENS: Intuitive Controls:

1. Learning the Fitocracy controls was easy.
2. The Fitocracy controls are intuitive.
3. When I wanted to do something in Fitocracy, it was easy to remember the corresponding control.

INTERVIEW GUIDE

INTERVENTION GROUP INTERVIEW QUESTIONS

**Question items will slightly vary across interviews due to the semi-structured, open nature of qualitative interviews. All questions will ask about the time frame of the last six months.*

PART I: Actual Intervention

1.) **Why did you participate in this research study?**
   Possible follow-up question:
   a. What made you think of changing your lifestyle?
   b. Why?

2.) **What helped you in your effort to increase your physical activity?**
   Possible follow-up questions:
   a. Why?
   b. Tell me about other elements that motivated you to be physically active
   c. Why do you think that is?
   d. Did this study influence your physical activity participation/levels?

3.) **What obstacles did you experience trying to be physically active?**
   Possible follow-up questions:
   a. Why?
   b. Tell me about other obstacles that you found challenging. Why?

4.) **Can you just walk me through the process of how you used Fitocracy so far, from the first day of study to today?**
   Possible follow-up questions:
   a. Which elements of Fitocracy website and/or app did you use? (show them interface) Why?
   b. Did anything stand out positively? Why?
   c. Did anything stand out negatively? Why?
   d. Where did you exercise? Why?
   e. When did you have the opportunity to exercise, but did not do it? Why?
   f. When were you motivated to exercise, but ended up not actually doing it? Why?

NOTE: If participant did not engage with Fitocracy, ask them why?
Possible follow-up question:
What would you like to see in an application to help with motivation for physical activity?

PART II: Logistics of Intervention

Introduction: Now, I would like to get your experience of being part of this research study and discuss issues related to the research process.

5.) **How was your experience participating in this study?**
   Possible follow-up questions:
   a. What was easy?
   b. What was difficult?
   c. Why?

PART II: Logistics of Intervention continued

6.) **If you could make any changes to this research study process in the future, what would you change in relation to:**
   - **a.) Appointments**
   - **b.) Questionnaires**
   - **c.) Accelerometers**
   - **d.) Fitocracy**
   - **e.) Location**
   - **f.) Research staff**

   Possible follow-up questions after each point above:
   a. Why?
   b. How would you change it specifically?

INDIVIDUAL INTERVIEW CODES DEPICTION

Table 1: Initial Code 1

	Motivation for enrolling in the study
I1	-**I'm friends with Ernie** and he told me about it and said, "Sign up!" I said, "OK"
I2	-I have always wanted to **participate in a research study** where my health is not really compromised in any way like some pharmaceutical -I felt like I was **contributing to something positive**
I3	-I was **interested** because I wanted **to see if it worked** -the reason I did it was because **I just finished last year my own research classes** at school and so I thought I'd like to see it from this perspective. It's part of that **giving back thing** for me.
I4	-I thought it would motivate me to **lose weight**
I5	-I thought it would be interesting to see what kind of **changes my body would go through**
N1	N/A
N2	-I thought it might be **interesting**, and **you guys needed volunteers**
N3	-I want to **get fit** and I was **curious about the study** and I was trying to **help a fellow colleague**
N4	N/A
N5	-I was hoping to actually find something to **help me get on my feet and moving**
D1	-I thought it would be a **good opportunity to increase my level of physical fitness or physical activity** -there were a **few things that I actually generally wanted to try**
D2	-to **help out**. Just to **give something back**.
D3	-I thought it would be a **fun new experience** -I'm a pretty inactive person and I was kind of **interested to see how this was going to impact** that, if at all.
D4	-I thought it would **encourage me to increase my activity because it's being monitored**
Extra	-I thought that **I needed some help to start moving**

Table 2: Initial Code 2

	Motivators and drivers for physical activity behaviour
I1	-it was my **husband** -maybe my **sister**. Yeah, she's another person -and then of course **Ernie**
I2	-**I was very excited that I could actually do this** -one of them was part of a **100 mile challenge** that I had with my **best friend**, so I was motivated to be here -the accountability of **the study** in a sense -I have my **wristband**, so I'm going to go run -there were times I had **my buddies** -it's a **golden retriever mix**. That was one of my motivators.
I3	-I'm at a point where my life was extremely sedentary and **I could feel the effects of it** and so I thought, well maybe this will do it. -I found some **classes** I could take early in the morning, 5 am, so that's what helped me. -going to the **class at 5 am** and **marking off on Fitocracy**, those 2 things together worked really well. -I need an **instructor** and we're going to be there and she'll lead me through. -my main motivation is just **to feel better**, **that fluid feeling when you can move your joints.**
I4	-I thought it would motivate me to **lose weight**
I5	-I thought it would be **interesting** to see what kind of **changes my body would go through** -but still **that number** is a big motivator as well -I started to develop a **really bad heart burn** -I **don't sleep**, I'm **not exercising**, **I'm gaining weight** -thinking I'm 33, and my **body's going to hell**
N1	-the motivation was more **personal** -I think it was **wanting to remain active in my life as long as possible** - I see on the street or at the store **people walking with a walker and think, I don't want that to happen to me**
N2	-maybe **it might get me to actually exercise** -I know I need to exercise. I know it's good for me. I know it's healthy. **I hate gaining weight**. -the constant presence of the **accelerometer**
N3	-age, **slow metabolism**, I have been thin, very size 0 think my entire life, **until about 2 years ago. So that for me has been a really hard transition**
N4	-but **her situation** is one thing that would motivate me, if I was here and if I didn't have physical issues I would have started because her situation is serious and it has to do with health, **she has diabetes** and diabetes runs in our family so that in itself would definitely be enough to give me that kick to get it together
N5	-**being accountable to somebody or something** maybe sparks that motivation a little bit more -having the **watch**
D1	-**friends** -wanting kind of a **change of pace**
D2	-our **diet** and our **weight** and our **health** -before I was pregnant, I weighed about 150 pounds. I now weigh about 190. So that's a huge motivator. Just looking at old pictures of myself is huge – I really **want to get back, you know, to where I was**, **even better**. And my **daughter** – she's my biggest motivator -just the fact that I knew someone, **"big brother", was watching** was kind of a motivator, a little bit.
D3	-having **friends** or even **family members** or whoever that **I can exercise with** is a big thing for me
D4	-I am very **goal driven** -I find that I am more consistent if I did the **short-term day-to-day thing** than if I did the big goals -I want to **fit in my clothes** -I **don't want to buy new clothes**
Extra	-I wanted to **lose a little weight** -I have a **back problem**, so I wanted to do something to be able to **move without feeling pain** -some of the **clothes I own don't fit** -some of **those questions made me think**, year I really need to do this. And I kind of saw **the study** as a trampoline for me to start working out again. It gives you motivation **to wear the little thing on your wrist**.

Table 3: Initial Code 3

	Barriers and obstacles for physical activity behaviour
I1	-I think I come back from work, **I just don't want to do anything. I'm just tired**; I just want to enjoy my evening and **just spend time with the family.** -I think It's the **energy level** for me -maybe **I'm just not quite motivated**
I2	-I battle with **depression** -emotionally, physically and spiritually **exhausted** -just gone through **breakup** -my **board exam** -the **whole transition period** and leaving school, having a lot of pressure to take my exam, finding work and being jobless and not having money is one of the things that physical activity just goes to the back burner -I do battle with **guilt** sometimes -I suffered a **medical condition** a couple years ago; became very deficient of Vitamin D -I would feel a lot of **pain** in my knees
I3	-I had an **injury** and it just threw me off -physical therapy took so much **time** and there's only so many hours in the day and the end of grad school pretty much killed me -**school schedule**, **single mom**, **four kids** -having to **sleep** is a problem
I4	-when I get home I don't want to exercise because my **poor wife will be stuck with the child more**
I5	-I just have not found the **time** to be working out -suddenly my **wife's grandmother died** ten days before our second **son was born** -after our son is born, a couple of months after that **we had to move** and so there's all that comes with that -I think **my life situation** made it really hard to give Fitocracy or this study any kind of priority -being healthy and being active **isn't a priority for me**
N1	-**injury** to my toe -daily **work-related fatigue** -I also get **headaches** -to **change from work clothes into exercise clothes**, and vice versa
N2	-but I **dislike**, actually **exercising** -**work** and **school** -**laziness**
N3	-it's just **starting**, that is my biggest barrier -**enjoying it**
N4	-I actually **hurt my arm** -I had **surgery** for my nose -I think I would work better **if I had a partner** to go and do something physically active, but I don't because I am here by myself
N5	-**juggling time** and **prioritizing**, you know, **I always put myself as the last** -**going to the gym or exercising makes me feel embarrassed** because I know that I am not like other people would be
D1	-my **schedule is so inconsistent** on a day to day basis -**distance** because one of the fitness classes that I wanted to attend was like 30 minutes away.
D2	-I don't have **time** -I **fatigue** easy
D3	-It's difficult for me to **exercise by myself** -I'm a little bit of a **lazy person**
D4	-exercise has always been a challenge for me. Busy, busy, busy, there is **no time**.
Extra	-I have been struggling with getting to work out again -My **personal will** and **laziness** -I **don't have a car**

Table 4: Emerging Code 1

	Initial reaction to Fitocracy
I1	-I **got to learn** to use this **and do it**
I2	-When it was taught to me I found it really **easy to use** (C)
I3	-I didn't know anything about the program but I thought **we'll do this** and see what start to happen -**I love**, I'm kind of addicted to **programs**, I always try something new
I4	-the way the app was presented to me from the study was **not conducive to using it at all** -I was expecting the person to upsell me on the app saying this is the way to get excited and motivated and check it out; this is how you use it.
I5	-well, I'm not really an athlete, per se. To me, as a musician, artist, whatever… that mindset, I could take it or leave it. It was kind of like, oh, well that's great. I see that other people might want to achieve, this level or the next one. **I didn't really care about that**. What I cared more about was how was this going to translate to the real world. Am I gonna see results?
N1	-the research assistant helped me set up a profile
N2	N/A
N3	N/A
N4	- but when it was first introduced to me I already knew even if I didn't have issues with my hand and the surgery, I already knew that **I didn't want to use it** because when it was introduced to me and the person who went over it with me, I don't remember who it was, **they told me it's like Facebook**, where I guess you have to post stuff. So here's the thing, **I have a Facebook but I don't hardly use it**, so I'm not that kind of person that will even want to post things. So it sounded exciting when the person told me what it was about, I thought 'Oh, that's nice I guess other people can encourage you" and it's like a log to track what you are doing. And that's great but I don't know I just didn't want to do it. **I didn't find it interesting**.
N5	-N/A
D1	-so, initially **I kind of liked the idea** of the Fitocracy app
D2	-**I didn't really like the Fitocracy** -at first I was like, **this is kinda cool**
D3	-my initial impressions of Fitocracy were that **it reminded me a lot of Facebook** and unfortunately **I am an anti- Facebook person**, so unfortunately **that was kind of a big turn off for me**. Social media in general I really dislike. I used it when I was originally being shown it and how to navigate I did it there with the assistant or whoever was showing me around. But I don't think I logged on at all after that.
D4	-**It's very convenient** and **I like that there are people doing some stuff**, but **I'm not really a social media kind of person**
Extra	**-I enjoyed the Fitocracy app.** (A, C, R ?)

Table 5: Emerging Code 2

	Enjoyment aspects related to Fitocracy
I1	-I tried again at another time, so I did enter a few more, but **it really was not helpful to me**, **I didn't enjoy getting on there because it was more frustrating for me than helpful.** (C)
I2	-it was just **really lovely**, people responded and I was like what a **nice community**; **I really liked it** (R)
I3	-I just **loved seeing the calendar**
I4	-the app had a lot of **good help on how to do exercises** (C)
I5	N/A
N1	-the little **robot** was cute. Fred was cute. And it did use **humor**.
N2	-it was really cool that when I did log an exercise, people I didn't know, would give **props**. It's nice to see that someone likes that I'm exercising. I mean, it didn't really influence me, but it was nice. (R)
N3	-the biggest positive was the **social support** (R)
N4	N/A
N5	-I just did have the one person that kind of like basically mainly **cheering me on**, that was nice (R)
D1	-sometimes I got disappointed in the number of points I got but **I did find it helpful** -I think **aesthetically it's pretty cool**. I like the fact that they have a **calendar** that you can go back and log days if you skipped a day and log it, that was pretty helpful. And most of the exercises that I saw you could **log reps as well** as time which I thought was also helpful
D2	N/A
D3	-I liked the ability to input your exercises and how long you exercise and the vigor in which you exercised -I liked **tracking** -I really like that about this app, **the ability to put in whatever I was doing** (A)
D4	N/A
Extra	-it's good because it has **a lot of options** of how to do workout programs (A) -I'm a competitive person, so the fact that I could gain some **points** was fun! I didn't think that I would get so excited about it, but I did. -the points were cool, but it's nice because if you do all the **challenges** you get the different **levels** and you get into it. (C)

Table 6: Emerging Code 3

	Dislikes related to Fitocracy
I1	N/A
I2	N/A
I3	-it was just like **documenting too much**
I4	-the first thing I saw was there was **someone in there who had this massive amount of points**. And if you don't exercise and the first thing you see is someone with 5000 points, forget it, what's the point, **I don't want to compete with you.** (C) -the other thing that did not appeal to me is that **I do not like to share my stuff in social media** -social media, **peer pressure** show off my results which I could care less about and **I don't want people knowing what I do** (R) -it was very **cumbersome to scroll through** and **find ways to do things** (C) -making me **feel guilty in front of people** and **report** and **compete**, especially **the privacy thing** (C)
I5	-I didn't want to have to keep **logging** each exercise and notating sets and the reps and what not
N1	-you were supposed **to connect with strangers online**, didn't really make as much sense to me. Because I didn't know them in real life. (R)
N2	N/A
N3	N/A
N4	N/A
N5	-Fitocracy did not work for me. **It just added more stuff for me to do**. And for me it became **overwhelming.** -most of the **challenges were way ahead of my level** (C) -the only thing for me in particular was **having to make time for it.** Having to go home and think, now I have to log in.
D1	-there are some things that are just **not easy to find** I think, within the app, if you type in something yourself. And so that was a little bit of a deterrent for me. (C) -they have at least one workout that I did and I really enjoyed and I think the other thing that towards the end I was like oh man if I go exercise now I have to make sure I log it into this thing -I just didn't know how to do it but there are some things that I did more than once and I still had to go back in and find all of them even if I did the same exercise two days ago I had to go back and try to locate that within the application. And I think sometimes the way it is organized depending on where you look you'll get different answers. Some of them is this workout and some of them is this physical activity, you know where you can customize it and so **entering information on the customize part was a little bit more complicated** (C)
D2	-it was kind of demotivating because the physical activity, **the exercise that I was doing**, the program **wasn't a part of it**; it wasn't an option that I could choose in Fitocracy. so **I didn't know how to record it** (C) -my excuse is not having time to workout, let alone having to go on the computer and **report it**
D3	N/A
D4	N/A
Extra	N/A

Table 7: Emerging Code 4

	Usage of overall Fitocracy application
I1	-**I would do it for a while and then I'd forget**
I2	-**I didn't use it** mainly because I was attached to something else and I felt like it was an extra step into it all and the fact that I wasn't regularly exercising -**I did record a few times** -I never used it enough to grow attached to it to use it regularly -I joined a couple of those where people would post up their favourite trails and give ideas and take pictures
I3	-it did work for about the first 3 or 4 months
I4	-**I did not use it at all**
I5	N/A
N1	-**I was using the track your workouts**
N2	-So, I didn't chart just walking around everyday stuff. I didn't really feel like it was exercise. **But if I did decide to jog or go on the elliptical then I would chart that**. However, that was few and far between.
N3	N/A
N4	-I think if it was something private where you can log on and it was your private account, perhaps then I would have been a little bit more interactive. But I understand the whole purpose was to get encouragement from other people or tips on how to work out and maybe it could have been good but **I didn't give it a chance**.
N5	**-I used it in the beginning; I tried it.** It was cute and fun but then I kept forgetting so I was like, forget about it. -**the challenges**
D1	-it was just like **log my activity** and **calculate my points**
D2	-I don't think I interacted, I just **read a lot of what people were posting**
D3	-I used it when I was originally being shown it and how to navigate I did it there with the assistant or whoever was showing me around. But **I don't think I logged on at all after that.**
D4	N/A
Extra	-I honestly **never followed other people** -I used it mostly to **look for exercises to input** my exercises to see on **how I improved from one week to the other**

Table 8: Emerging Code 5

	Feature usage within Fitocracy
I1	-it was kinda neat to **keep that record** -I looked at it, but it really was **not interesting to me**
I2	-I really liked **the groups** (R)
I3	-the **tracking feature** is only really what I needed -the quests they have different **challenges** you join and it **coaches** you even higher and I actually recently reached out to them to see about a program to start over and taking it slow. But with the end of school, it's just not, and there was a cost to it. **I'm just not in a place right now, coaching is a pay features**. -those motivational rewards don't last for me; I was really trying to focus on how I felt. To me at this stage, a badge and points, **I'm just not interested in playing that game.**
I4	N/A
I5	N/A
N1	N/A
N2	N/A
N3	N/A
N4	N/A
N5	N/A
D1	N/A
D2	N/A
D3	-…the **point system**. But for whatever reason that **did not just do it for me**.
D4	N/A
Extra	N/A

Table 9: Emerging Code 6

	Competence factors within and outside of Fitocracy in relation to physical activity
I1	-it **wasn't that easy** for me. Maybe **I'm just not savvy** when it comes to these applications -I **couldn't figure out** how to enter it once I've already exercised -I think it's just **a matter of being better trained** how to use the application
I2	N/A
I3	N/A
I4	N/A
I5	N/A
N1	-I didn't feel that it was helpful because I did try to log in and track when I had done something significant, but **I never really got good at figuring out how to fill out the form**, in it, about – I could tell I walked for this length of time, but **I didn't know how to translate that into distance** -in order to get it to give you points or submit what you are telling it, you had to give information that **I did not know how to figure out** -**I didn't really figure out how to tell Fitocracy's software**. It said that it had a way to put a workout in one time so that then you could tell it in the future that you were doing that workout. And **I didn't quite figure out how to do that in that software**. So that meant that I didn't really keep up with telling it always what I had done -**it was more difficult to use than it had first appeared**
N2	N/A
N3	N/A
N4	N/A
N5	-**most of the challenges were way ahead of my level**
D1	N/A
D2	-**I'm not technology savvy**. I don't really like using my phone.
D3	N/A
D4	N/A
Extra	-the way it works **is very simple**. **It's very straightforward.**

Table 10: Emerging Code 7

	Relatedness factors within and outside of Fitocracy in relation to physical activity
I1	N/A
I2	-I felt like there was this **community of people that was excited** about the same thing you were and it wasn't just about general fitness. People talking about weight **interesting*, and I really appreciated that.
I3	-Funny story, because you start to get people following you or whatever, so the first one that came through, Oh hi. I kind of responded, Oh, thank you. Then I noticed this person kept doing it no matter what time I exercised when I entered it, that person was there saying good job. I was like you cannot be a real person. That helped but I didn't jump into the environment of Fitocracy**. I have my friends, real people.**
I4	N/A
I5	N/A
N1	-and the other parts like—this person gives you applause, this person said way to go—and you were supposed to **connect with strangers online**, didn't really make as much sense to me. Because **I didn't know them in real life.**
N2	-**I tried to search for other study members** because I figured it would be a similar pattern with the birthdate. So I'd be like, hey, you can add friends on here, maybe I can find other study people.
N3	**-the biggest positive was the support, the social support.**
N4	N/A
N5	- you know **the other people motivating you**, it was not that much, **it did not make much of a difference**. I just **did have the one person that kind of like basically mainly cheering me on, that was nice**
D1	N/A
D2	N/A
D3	-**I like the face-to-face interaction**. **I feel like a lot of communication gets lost when you're talking in the box**. There are just so many things, like tone of voice, body language so many things that communicate more about what your saying than the actual words that you're saying and to me that's such a severe limitation of social media I just haven't been able to overcome it.
D4	-maybe if there were **5 of us friends that said we would do this together** and we would compete and then perhaps then I would track because there is a number of here that is using the fit bit and we are tracking each other.
Extra	-sometimes I would see that people would give me props and like "Ok, yeah, sure." Um, like I said, **social networking—I use it to communicate with friends and family; not to socialize with people that I do not know.** -**the personal contact always makes a difference**, at least in the beginning stages. We're going to do this. Try this with you. And probably in the first month I would have a personal accompaniment, but then here we can work on a transition for an app that I can have anywhere. And I don't need to have that person there 24/7. That, I think, would've worked.

Table 11: Emerging Code 8

	Attitude toward and opinions about accelerometer usage
I1	-**I felt like maybe I could keep it on longer** because every time I put it on, those were the weeks I don't exercise
I2	-the accelerometer was **so ugly** -**I was always just trying to hide it** to make it look like a bracelet or something else
I3	-**it was ugly**
I4	N/A
I5	N/A
N1	N/A
N2	-**sometimes it would get itchy**
N3	-clearly they **should be smaller**
N4	N/A
N5	-**I wish we would have longer than just a week. Because you know for me it helped me with the positive pressure.**
D1	N/A
D2	-**I hated wearing it** -I think **I just found it frustrating**
D3	N/A
D4	N/A
Extra	N/A

Table 12: Emerging Code 9

	Attitude towards and perceptions regarding the questionnaires assessing motivation for physical activity
I1	-the questionnaires were **boring** for me to go over the same thing every single time I went in. -I felt like they were **repetitive**
I2	-I really **felt confused**; I felt like I was doing the **same survey every visit** -it did feel a **little long**
I3	-I always questions myself; am **I answering this based on what I'm feeling or what I think they want to hear?**
I4	-whoever wrote those, I don't know why they wrote them that way -why would you use **triple negatives on the questions**? -I don't know if there was a purpose for that, but **I didn't know half the time what you were asking** -**were you asking this or are you asking that**? -I made fun of the questions every single time to the assistant and I am sure they told you that
I5	-they were **long** questionnaires -perhaps you could do something with the **format** next time; **make it bigger**; it could be a **little easier on the eye**
N1	-I think it was **hard to scroll up and down on the screen**
N2	-my main issue with the questionnaire was the **computer itself**, the questionnaire seemed fine
N3	-**length** and **repetition**
N4	-I felt like they were **really long, very long** -I felt like the **questions were similar**, **repetitive**; they just switched some words around
N5	-I would have appreciated the top bar classification to scroll so the little dots were…
D1	-they **were not that long** -sometimes I would read it and was like, **this is the same question**, and so **that was a little frustrating for me**
D2	-**I didn't have any complaints for them**
D3	-I thought they were a **little long** and **tedious** -I felt like a **lot of the questions were asking the same thing**
D4	-those were **long**
Extra	-**the length on each page**; **it's too big**, when you go too low, it kind of disappears.

Table 13: Emerging Code 10

	Opinions about and suggestions for assessment appointments
I1	-I actually liked the way you guys did it. You guys sent me **reminders** -you guys were **very flexible** with me so I'm **really happy with that**
I2	-something that I feel like would have benefitted me in the being more motivated, was just having **conversations** like how was your week or tell me about your friend. Even if they were very neutral and it was just talking out loud, I would probably just have that time to reflect.
I3	-it was **very smooth**, **flexible**, most of the time
I4	-the appointment was **good**
I5	-it was really **easy to reschedule** and although you had somewhat limited hours to do this -I thought it was **good**
N1	N/A
N2	-sometimes when I found the **appointments convenient** and then **sometimes where I didn't** -I think maybe **having more appointment slots** would've been nice
N3	-that was fine, nothing I would **change** about it, **nothing**. -**very flexible, very nice**
N4	-I found the appointments were **very easy** -it was **flexible** -I was **happy that there was time available after 5 p.m**.; so that was a good thing and also your **text reminders** that was a good thing. -I always **loved those reminders**
N5	-they were **flexible**, come on the days that you could -reminders that were there
D1	-I think the appointment scheduling was **fine**
D2	N/A
D3	-it was nice to be able to have that **flexibility** in working with you and the research assistants
D4	-**I like the follow-up text**: "you have an appointment today"
Extra	-that went **pretty well** -everything was **well organized** and **they were coming to get you**

Table 14: Emerging Code 11

	Opinions about and suggestions for assessment location
I1	-very **convenient** for me because I live…, it's like on my way home from work
I2	N/A
I3	N/A
I4	-that place is a **nightmare to find parking** **-it's easy to get to**
I5	N/A
N1	N/A
N2	N/A
N3	N/A
N4	**-I felt comfortable going there**
N5	-to me it was **perfect** because I live down the road
D1	N/A
D2	-the **location was actually kind of convenient for me**
D3	N/A
D4	N/A
Extra	N/A

Table 15: Emerging Code 12

	Opinions about and suggestions for research staff
I1	-they were all so **friendly and nice**; **very, very nice**; **very positive experience**
I2	-I really liked that they could be **friendly**
I3	-I was surprised at how **they didn't engage a lot** -I was just kind of **surprised at how efficient it was** -**very kind and very polite** -**I just expected a little more personalized engagement**
I4	-I think they were **fairly nice**
I5	-I thought your students were really…**performed well** -they were **engaging and personable** -it was a **pleasant experience**
N1	-they were **very professional**
N2	-they were **very friendly, very professional**
N3	-they were all **very, very, very nice**
N4	-they were **helpful and friendly**
N5	-everybody was **wonderful, excellent staff**
D1	-they were pretty **knowledgeable** and so ideally it would have been nice to see the same person but I think it would have limited my scheduling options, so that's understandable -**they were great; very nice, very pleasant** -**always on time** even when I wasn't -I remember one day I missed my appointment and they squeezed me in so it was good
D2	-everybody was **great;** they were all **friendly**
D3	-they did a **pretty good job** -I feel like **sometimes it was kind of a canned interaction**; it was almost like they had some kind of a script they memorized and were kind of repeating it verbatim almost, but other than that, everybody was **nice and answered any questions I had and it was good**
D4	-they were **friendly**
Extra	-they were all **very, very nice; very pleasant**